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THE RECENT ERUPTION OF MAUNA LOA, HAWAIIAN ISLANDS.

LATE VOLCANIC ERUPTIONS IN THE HAWAIIAN ISLANDS.

THE Hawaiian archipelago, situated in the Pacific Ocean, consists of eleven large and small islands, and they are governed by King Kalakaua, whose Queen, Kapiolanapi, lately visited our shores. High mountains of volcanic nature run through these islands, and some of the continually recurring eruptions have been severe enough to keep the inhabitants in constant fear.

There have been eruptions nearly every year, but those specially remembered as having caused great devastation took place in the years 1855, 1868, and 1881.

Since 1881 no great eruption took place until the middle of last January, when the Hawaiian volcano Mauna Loa, the largest in the world, awakened out of its short rest, and became fearful in its destructive activity.

Enormous streams of liquid fiery lava, mixed with smoke and gases, rushed out of the newly opened crater, and during thirty-six hours there was an almost unceasing series of fearful earthquakes, that threatened to destroy the entire island, while communities were carried off by the irresistible power of the tidal waves.

There was a short period of quiet after the first terrible effects; but the eruptions commenced again with trembling of the ground, and the unhappy inhabitants were in agony for several weeks.

According to the latest reports, the internal fires have not yet subsided, which fact gives rise to the greatest fears.

A new and enormous lava stream has begun to pour forth from the highest crater, Mokuaweoweo, situated on the back side of the mountain, toward the south, called the Kona side.

Another large lava stream flows down incessantly toward the lower crater, Kilauea, which includes also the fiery sea Halemauman. The lava stream has fortunately taken a direction toward Kasuku, where there are but few settlements. If it should, as feared, go farther south toward Punalun, there would then be a prospect of boundless destruction and loss of property. For the foregoing particulars and for our engraving we are indebted to the *Deutsche Illustrirte Zeitung*.

We add the following, which a correspondent has sent to the *Vossische Zeitung*, an interesting account of the great eruption of Mauna Loa, and the other seismic disturbances which occurred at the Sandwich Islands in the early part of this year. The writer has personally visited the actual crater, situate near the summit, about 13,500 feet above the sea level. The district lying to the south, through which the river of lava pushed its course of havoc, is one vast and fertile sugar plantation. Kilauea, another crater of the Mauna Loa range, which is situate little more than half way up the mountain side, is much more accessible and better known. It is always more or less in a state of activity. The great eruptions, however, of 1851, 1855, 1859, 1868, 1881, have originated in the upper crater, called Mokuaweoweo. The lava does not flow over the brim of the crater, but seems to make its way downward by underground passages or through clefts in the mountain side, forming new reservoirs, out of which the overflow of lava pours with resistless force down to the plain. The writer in ascending the mountain came on one of these clefts, three-quarters of a mile long and about 25 ft. wide, apparently very deep, out of which the lava was pouring. A quarter of a mile higher up was a cone the side of which next the sea had fallen in, disclosing a boiling caldron of molten materials.

This liquid mass must have found a way underground to the great cleft just mentioned, and discharged its contents by it. Just a little above this cone another great cleft opened, which proceeded up the mountain in zigzag fashion to the crater Mokuaweoweo, the chief seat of the lava manufacture. For twelve days it sent down its river of fire fully 20 miles in length. The picture presented to the spectator at the spot was most remarkable—the snow-capped mountain discharging its glowing flood, at its foot the blue Pacific ocean with its world of islands. Fifteen pillars of flame shot up from the crater to a height from 150 ft. to 200 ft., while lower down the other lava reservoir sent up columns over 40 ft. high. The crater at the top of the lava river was about 40 ft. or 50 ft. across, and it was sometimes girdled by a sort of nimbus of fire.

In the 53 hours between 2 p. m. on January 16 and 7 p. m. on January 18, 618 distinct shocks of earthquake were noted. The lava stream was much more copious and energetic than in 1868. Then it was accompanied by an incessant rain of ashes, which covered the land for miles around; but this time it was clear, thick lava. The upper portion of the mountain seemed for miles wide to be a sea of fire, which swept away in its course great blocks of stone. Owing to the rapid development of the eruption immediately after the series of subterranean shocks, the island escaped the horrors of a regular earthquake, and the mischief was confined to great destruction of the plantations. Several days after the first outflow of lava (which lasted a fortnight) a fresh outburst occurred about 1,000 ft. below the Mokuaweoweo, and a new outflow established itself, following the direction of the stream of 1859, when the discharge continued with little interruption for 15 months. Explosions were being frequently heard, caused, no doubt, by expanding gases, which were followed by the projection into the air of columns of fire to a height of 500 ft.

ROSE GROWING.

SUMMIT is some eighteen miles from New York, and is a beautiful, hilly, well wooded place, fast filling up with handsome residences. As a rose growing depot it is famous throughout the country and in its neighborhood, and at Madison, some four miles distant, are located many of the leading cut flower growers who supply the New York market. Among rose growers is Mr. De Forest, who has one of the largest greenhouse establishments in the country, and Mrs. De Forest is just as much interested in all that pertains to flowers as is her husband. His greenhouses consist of many ranges of three quarter span houses, 20 ft. wide by 200 ft. long; also some 12 ft. wide and 6 ft. wide propagating houses, but nearly all run about the same in length. They are wooden houses, built of the best material and glazed with first quality French double thick glass. I use second quality double thick French glass, and think I am doing well, for it is clear, fine glass; but Mr. De Forest believes that the first quality is more than worth the extra cost. He has resolved not to build any more houses of wood, and is now clearing ground for iron structures. In the rose houses the beds are not made upon the ground, but in all cases are raised above it on plank benches. There are two sets of greenhouses, a few hundred yards apart; one is heated by steam, and the other by hot water. Mr. De Forest greatly prefers the steam heaters; they are very efficient, quick to act, easy to regulate, easy to stoke, and so far as fuel is concerned very economical—eight tons of coal in the steam heaters giving the same results as fourteen tons in the hot water apparatus. The steam heat has no injurious effect whatever upon the plants.

The roses grown are Bon Silene, La France, Niphetos,

Catherine Mermet, white Catherine Mermet, Bennett, and American Beauty; also, but in more limited numbers, Captain Christy, Her Majesty, Paul Neyron, Magna Charta, Mme. Gabriel Luizet, Jacqueminot, and a few other hybrid perpetuals. All the teas are now in fine growth and flower, but of the hybrid perpetuals some are being started, while others are not yet "shut up." Bon Silene, La France, and Niphetos occupy the back and front branches, which are raised to pretty near the glass, and are planted out and kept tied down. Niphetos is not upon its own roots. Mermets comprise the majority of the stock grown, and are beautiful. They occupy the central beds, and are in most cases planted out, but one house is largely filled with them in pots. The majority are one year old plants, but one house is nearly filled with two year olds. One year old plants are said to yield the largest crops, but two year olds the finest blooms. A cane stake is applied to each plant. The white Mermet is in every way, except in color, the exact counterpart of its parent. It originated with Mr. De Forest, who considers it distinct from the white variety obtained about the same time by Mr. Taplin, of Maywood. Bennett is growing and flowering freely, planted out on the front middle benches. But the American Beauty is truly a beauty. Planted out in the middle benches, in fine luxuriance of wood and foliage, and with one bud terminating each shoot, it does not stop till it has nearly reached the glass. Its large size, deep rose red color, and delicious fragrance, also the long, leafy stem that may be cut to each rose, add much to its value. Mr. De Forest says that so far he has not succeeded well with Her Majesty, but he is now satisfied from observation elsewhere that he has found out the cause of its backwardness with him, and that is that it needs a lighter and more porous soil than he generally uses for his roses. Mme. Gabriel Luizet is his great favorite, and he has recently imported it largely. Paul Neyron and Magna Charta are grown for March flowers. Their immense size always commands attention. Jacqueminot for color stands unrivaled. Mr. De Forest is very found of Captain Christy, and grows a lot of it because he himself likes the rose, and not for market, as it is too small for that purpose.

The soil used is from rotten turf. In the neighborhood is an old apple orchard that had been in grass for many years, from which he bought the turf. He turned over the top, carted it home, and made a pile of it, putting a layer of loam and one of manure alternately, but about twice as much loam as manure. This was done in the autumn, and it will be allowed to remain in the heap till next May, when it will be turned over and used for the bench beds. Clean cow manure alone is used for manure. All the beds and pots are mulched about 1 inch or 2 inches thick with it. There are large tanks of liquid manure in the greenhouses, and steam pipes run through them to warm the water. It is applied by steam pump power. Mr. De Forest believes in limited, rather than a liberal, use of liquid manure, and not at all till the roots have first pretty well exhausted the soil.

Mr. De Forest apprehends a great future for orchid flowers, and has resolved to supply the market. He now has, I should think, between one and two thousand plants, but this, he assures me, is only the beginning; he intends to fill several houses (and each of his houses is 200 feet long!) with orchids alone. He does not mean to displace roses to make room for orchids, but to add more new greenhouses.—*William Falconer, in American Florist.*

SPRING TREATMENT OF ASPARAGUS.

THE time has now arrived when the formation and renovation of asparagus plantations must receive attention. Few cottagers care to cultivate asparagus, but amateurs delight in having a good bed of it, and no garden under the charge of a professional gardener can be without it; in fact, in many gardens it is regarded as the most valuable crop of all, and a liberal supply of first rate produce never fails to give the utmost satisfaction to all concerned. Forced asparagus is a delicious dish, and from the end of April until the middle of June the open-air produce cannot be equaled by any other vegetable in season. Peas and other good vegetables may be late, but so long as there is plenty of asparagus this absence will not inconvenience any one; and I would strongly advise all who value choice vegetables at this time to grow as much asparagus as they possibly can. It is no uncommon thing to see the most ordinary crops, the half of which will never be consumed or prove remunerative, occupy large quarters in vegetable gardens, while choice asparagus is only planted and grown to a very limited extent; and I feel absolutely certain that were the asparagus planted extensively to supersede the common produce, the result would be beneficial to all. I have long considered it a waste of all material to attempt to renovate an old asparagus bed when the whole of the roots that remain only consist of a few at great distances apart. If there is only a blank here and there in the plantation it may be made up, but success will never attend the planting of a great many young roots among a few old ones, as the latter hinder the proper preparation of the ground for the reception of the young roots, and this is a very important point.

Many asparagus plantations fail through the soil in which they are planted not being properly prepared, and not a few also fail in the soil being too much prepared. Some have an idea that asparagus cannot be too well done, and all kinds of useful, useless, and superfluous manures are put into the soil with the object of securing uncommonly fine produce in an unusually short time; but the result is more often failure, and then the cultivator cannot understand it, as the bed was so complete in its composition. Any ordinary good soil will grow first rate asparagus, and after applying the necessary manures and cultivation, the less it is meddled with the better.

The "asparagus bed" is such a familiar term, that many who purpose beginning its culture would never expect to succeed with it unless the roots were planted in the orthodox bed; but this is wrong, as the old fashioned, high sided, neatly cut out bed is rarely patronized by good modern growers, but a good piece of ground is planted row after row, through and through, and there is then no ground lost by wide pathways between the beds, while the results are remunerative in the highest degree. If I had 150 new asparagus plantations to make, I would never think of giving one of them the form of a bed. The only soil to avoid in asparagus culture is a heavy, wet, retentive one. The roots are very fleshy, and in the summer they will push out a long way, but when winter comes they will not grow in a wet soil, and the greater part of them will die back until the plant is left with so few that growth the following season will be most unsatisfactory, if not quite a failure. This may lead those who have nothing but a heavy soil to work with to infer that their chance of growing good asparagus is hopeless. Nothing of the sort, as the whole may be easily remedied by drainage or the addition of light material. In dealing with a heavy, wet soil, it should be trenched to the depth of two feet six inches, and a large quantity of ashes and any old rough material should be placed at the bottom of every trench. This will act as excellent drainage and improve the soil as well, and a quantity of sand or road scrapings should be added to the soil near the surface. The quantity must be determined by the texture of the soil, but do not stint it in any case.

This trenching and adding to must all be done before manuring begins, but as soon as these operations have been completed place a heavy dressing of manure on the surface and fork it well through the soil, and the piece will then be ready for planting. I guarantee that a quarter treated in this way would produce excellent crops of asparagus for many years, but it ought to be understood that the utmost importance must be attached to the indispensable system of thoroughly preparing the soil before any attempt is made at planting, as once the roots are planted and established the soil should not be disturbed again to any extent for many years. The not uncommon plan of planting in a hurry in any kind of soil and letting the roots take their chance will never do in the case of asparagus, but with a properly prepared soil and roots rightly planted they will succeed permanently in spite of everything. There are many gardens, however, where the soil is naturally adapted for asparagus growing, and in these instances culture is very easy.

In preparing to plant it is only necessary to manure the surface well, and add a little sand or general refuse. Horse droppings make the best manure for asparagus, and of artificial manures, soot, guano, and salt are the best. Seaweed is also excellent, and wherever it can be obtained it should be used in preference to everything else. It may be dug into the ground like manure, and where the soil is poor horse droppings may be added to it. I do not, however, approve of dressing the ground with these manures and adding a quantity of artificial manure as well. Well prepared ground does not require artificial manure at first, and this should only be applied in after years as a stimulant. In selecting ground for asparagus odd corners must be avoided and the best part of the garden devoted to it. Sun and air are very essential to the perfect development of the stems and maturing of the crowns. In planting the roots great care should be taken that they are not allowed to shrivel or dry up when out of the soil. They may be transplanted most successfully from one to three years of age.

In buying roots from a nursery, I would insist on their being packed in a little damp moss, and they should not be allowed to remain a minute longer on the road or at the station than is actually necessary. Laying them in temporarily until their quarters are ready is a bad plan, as it is impossible to shift and reshift them without injury. Of this I have had ample proof. When the young roots are home raised and have only to be taken from one part of the garden to another, planting may be done without losing a single root, as they should be transferred without being out of the soil more than a few minutes. The roots are all star-like in form, and they may be crammed into a very small hole, but this is not beneficial, and the best way of planting is to allow them plenty of room to go in freely. Each hole should be taken out with a spade to the depth of four inches or five inches, and about one foot square. The root is then placed in without a twist, and free growth is sure to follow. In the bed system it was a general rule to plant one foot or a little more apart, and in a short time the top growths became a crowded mass, but this had a direct tendency to lessen the strength of the shoots, and the best of all results are obtained by planting each root about 2 feet or $2\frac{1}{2}$ feet apart from the other, and allowing the top growth unrestricted space. There is nothing lost in this, as there will be as many heads cut from a root thirty inches from its neighbor as there would be from two roots in that space, and the size of the former heads will be much in excess of the latter; in fact, first rate produce can only be secured from roots grown widely apart, but at whatever distance they may be put in, if they can be planted in wet weather it will be greatly in their favor, but if the weather is dry throughout the whole of the planting season, as it promises to be this year, water freely as soon as planting is done. One year old roots often succeed better than older ones, and the older they become the more risky is their transplanting; but, although they may be transplanted at three and four years old, none of the produce should be cut from them the first year, as the aim should be to allow them to become fully established before beginning to cut. Although I object to patching up very deficient beds or plantations, it is an advantage to fill up a blank when it only occurs here and there, and in that case planting is done in the same way as is recommended for the new plantation.

Asparagus is much benefited by being mulched in summer, and as soon as it is seen where the young growths are, a quantity of short manure should be placed round each plant. The roots being near the surface they are apt to suffer from drought, which this mulching will counteract and benefit them to a great extent. I do not know of anything that injures asparagus more in summer than wind. Let any one look over a plantation after the shoots have attained a fair height, and they will observe that many of the shoots have been broken short off at the root. This not only hinders the shoot from developing further, but it also injures the crown for the succeeding crop. This must be avoided, and the best way of doing it is to put a stake to each plant and tie the stems so firmly to it that they cannot be blown about, upset, or broken off. I may further remark that asparagus is very late this spring. Some years we have cut quantities of it by the second week in April, but this season we will not have a dish until May, as the heads are not yet visible. In cutting, at first, a number of the later stems may be destroyed if care is not taken with the knife, as those who push down and cut it as low as possible can easily cut over some of the young stems that are not visible above ground.

I have no doubt there are many of your readers who desire to raise their own asparagus roots, and it may interest them to know that it can be easily accomplished; one ounce of seed will produce hundreds of plants, and it rarely fails to germinate. It should be sown in drills three inches deep and fifteen inches apart. We sow a little annually to keep up a supply of roots for winter forcing. The seed is sown thinly, as then plants can be easily disentangled when they come to be transplanted at the age of two or three years. A rich light soil is the best for the seedlings, and, apart from keeping them free from weeds, their cultural requirements after sowing are nothing worth speaking of.—*J. Muir, in The Garden.*

THE AMERICAN EXHIBITION, LONDON.

THIS novel exhibition was opened to the public on the 9th of May, and bids fair to become a great success. Our engraving is from the *Illustrated London News*, in which we also find the following interesting remarks:

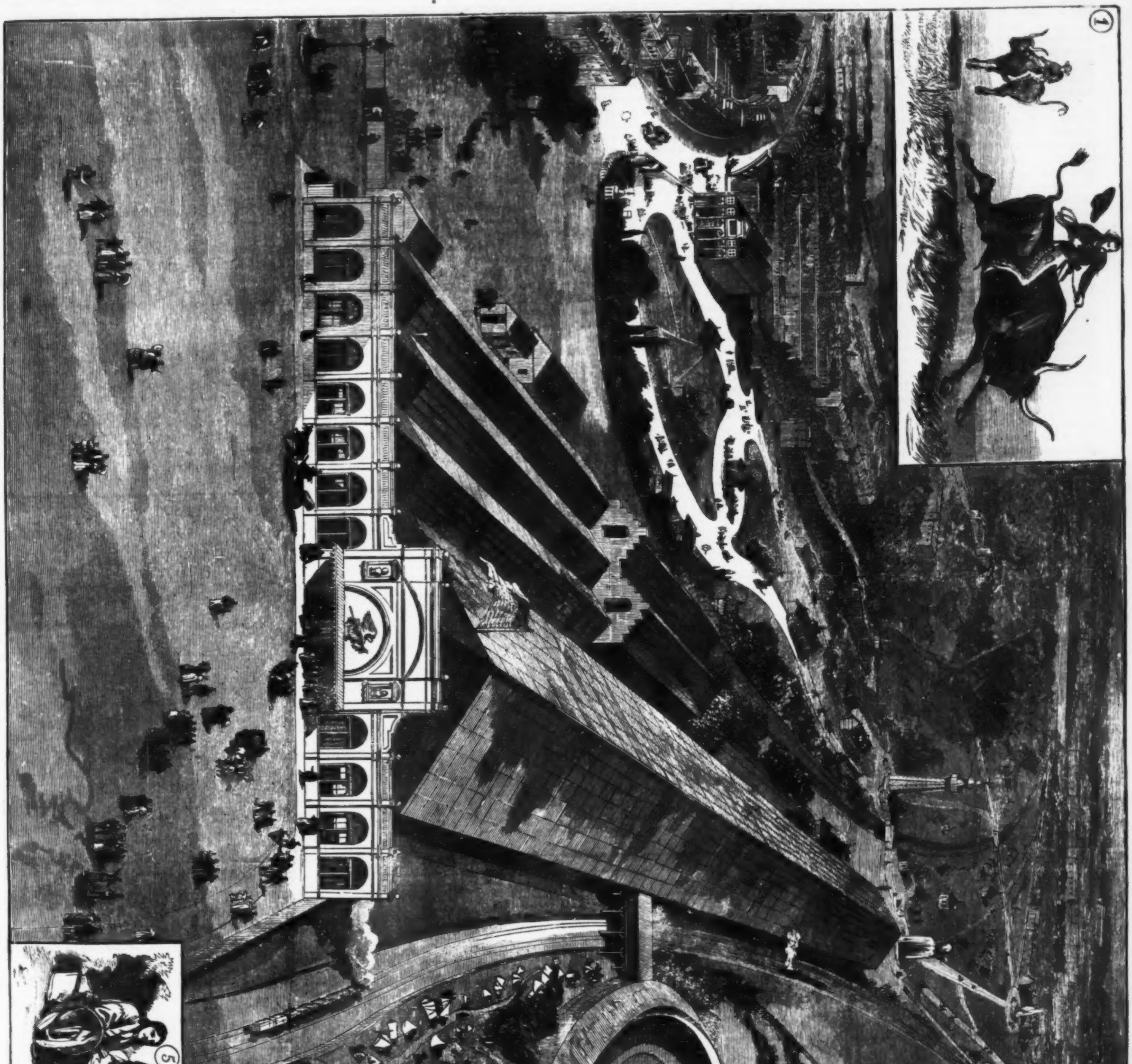
"It is certainly a novel idea for one nation to hold an exhibition devoted exclusively to its own arts, inventions, manufactures, products, and resources, upon the soil of another country three thousand miles away. Yet this is exactly what the Americans will do this year in London, and it is an idea worthy of that thorough-going and enterprising people. We frankly and gladly allow that there is a natural and sentimental view of the design which will go far to obtain for it a hearty welcome in England.

"The progress of the United States, now the largest community of the English race on the face of the earth, though not in political union with Great Britain, yet intimately connected with us by social sympathies, by a common language and literature, by ancestral traditions and many centuries of a common history, by much remaining similarity of civil institutions, laws, morals, and manners, by the same forms of religion, by the same attachment to the principles of order and freedom, and by the mutual interchange of benefits in a vast commerce and in the materials and sustenance of their staple industries, is a proper subject of congratulation; for the popular mind, in the United Kingdom, does not regard, and will never be taught to regard, what are styled "imperial" interests—those of mere political dominion—as equally valuable with the habits and ideas and domestic life of the aggregate of human families belonging to our own race. The greater numerical proportion of these, already exceeding sixty millions, are inhabitants of the great American republic, while the English-speaking subjects of Queen Victoria number a little above forty-five millions, including those in Canada and Australasia and scattered among the colonial dependencies of this realm. It would be unnatural to deny ourselves the indulgence of a just gratification in seeing what men of our own blood, men of our own mind and disposition, in all essential respects, though tempered and sharpened by more stimulating conditions, with some wider opportunities for exertion, have achieved in raising a wonderful fabric of modern civilization, and bringing it to the highest prosperity, across the whole breadth of the Western Continent, from the Atlantic to the Pacific Ocean. We feel sure that this sentiment will prevail in the hearts of hundreds of thousands of visitors to the American Exhibition about to be opened at the West End of London, which is a fitting sequel, in our opinion, to last year's Colonial and Indian Exhibition; and we take it kindly of the great kindred people of the United States that they now send such a magnificent representation to the Fatherland, determined to take some part in celebrating the jubilee of her Majesty the Queen, who is the political representative of the people of Great Britain and Ireland.

"The American Exhibition, of course, has in view also the legitimate aim of stimulating and extending the export trade of the United States, and quickening the flow of capital to America for the development of her internal wealth and resources. Its special purpose is to display, in the metropolis of Great Britain, the chief market of the world, a more complete collection of the productions of the soil and of the mines and manufactures of the United States than has ever yet been shown in England at any International Exhibition; and so to impress the people with a sense of the magnitude and the variety of the industrial resources of that country, and the skill and ingenuity of its artisans, as to extend its foreign commerce. The idea of this exhibition was conceived about three years ago. After much thought and toil, and the expenditure of many thousands of pounds, at length it assumed a definite shape; and very early next month, with the immense preparations rapidly pushed forward, Londoners and visitors from the country will be able to enjoy the result in what promises to be one of the greatest, the most original, and most instructive of similar exhibitions.

"The grounds secured at Earl's Court, West Kensington, consist of twenty-three and a half acres, of triangular form, with seven entrances, including three direct from different railway stations, namely, the Earl's Court Station, the West Kensington Station, and the West Brompton Station. The other entrances are in Warwick road, in North End road, and two western, in the Lillie road. It will be seen that the facilities for reaching the grounds are of unusual convenience. And the hearty co-operation of the railway companies who own the land occupied by the Exhibition makes it certain that tickets can be purchased at any station in England direct to the grounds.

"The Exhibition will comprise three departments. The first of these, occupying that portion of the grounds nearest West Brompton Station, consists of the main Exhibition building and the annexes, which contain the art gallery and the principal restaurant. The main building fronts the Lillie road, and is close to the West Brompton Station, on the west side. The south elevation is of light colored brick and stucco, and contains the exhibition offices. It is 210 ft. wide, and very graceful and pleasing to the eye. The main court, running northwest from this entrance, is 120 ft. wide and 1,260 ft. long. The framework is constructed mainly of railway rails, and is covered with corrugated iron and glass. It is not only very strong, but it is at the same time light, airy, and graceful. Only the floor



THE AMERICAN EXHIBITION, EARL'S COURT, WEST BROMPTON, AND WEST KENSINGTON.—1. LASSOING WILD STEERS. 2. INDIAN CAMP. 3. INDIAN CHIEF. 4. LASSOING WILD HORSES. 5. INDIANS.

being of wood, it has the additional advantage of being practically fireproof. This is laid out in streets and avenues running at right angles to each other, in the way that American cities are commonly constructed. On the southwest side is the principal restaurant, which is 90 ft. by 224 ft.; and northwest of this is the art gallery, 80 ft. by 160 ft. In this main building will be centered the serious interest of the Exhibition.

"The space could have been disposed of several times over, so numerous have been the applications received. The management has therefore had the opportunity of selecting only the very highest class of exhibits, and those in which America excels. There will be a very large proportion of exhibits of machinery in motion, and of articles in process of manufacture, as 'making something' is always attractive to people, a fact which was fully demonstrated by the popularity of the Indian Court at the exhibition last year. Agricultural machinery will also be a prominent feature, and there will be collections of canned goods, manufacturing jewelry, watches, and clocks, and an endless variety of novel and curious products of American ingenuity and invention.

"The art gallery will contain about one thousand pictures by American artists, and these will afford a good opportunity of judging of the progress in that direction made by Americans since the Centennial Exhibition at Philadelphia, in 1876. Interspersed with the pictures in the art gallery will be a collection of hunting trophies, brought from America by different sportsmen. Mr. E. North Buxton is at the head of the committee having charge of this interesting collection of hunting trophies.

"A large covered bridge, crossing the railway, leads from the main building eastward to the grounds near-escapes and deeds of daring, generosity, and self-sacrifice, which compare very favorably with the chivalric actions of romance, and he has been not inappropriately designated the 'Bayard of the Plains.'

"The third section comprises ornamental gardens and pleasure grounds, which are approached from the West Kensington Station, from North End road, and through the main building from West Brompton. They comprise twelve acres laid out in walks, flower gardens, and shrubberies. Here are music pavilions, in which Mr. Dan Godfrey and the band of the Grenadier Guards will give concerts twice daily, in the afternoon and evening; also several pavilions for refreshments, and some for special exhibits. In these gardens a display of American flowers, plants, shrubs, and trees will be made as complete as the London climate will allow.

"A great variety of amusements will be provided, including a diorama of the harbor of New York, designed by M. Bartholdi, the creator of the colossal statue of Liberty, a model of the switchback railway, roller toboggans, and other appliances, and entertaining spectacles. In the evening, the exhibition will be lighted by two hundred and fifty electric lights, each of two thousand actual candle power, and nine huge search lights, each of ten thousand actual candle power. It is wonderful to think of this picturesque and fairy-like park and buildings, created with magical quickness on a piece of waste land. And what will it be to see it at night, illuminated by lights equal to half a million of candles! The exhibition will be opened in May, and it is intended to keep it open till Oct. 31. The hours of opening and closing, prices of admission, and the general regulations will be pretty nearly the same as those now familiar to the public at the South Kensington exhibitions.

"The officers of the exhibition are as follows: Mr. John Robinson Whitley, London, chairman of the executive council, and director general of the exhibition; Colonel Henry S. Russell, of Boston, chairman of the board of direction in the United States; Mr. Burnet Landreth, of Philadelphia, director; Mr. John Gilmer Speed, of New York, secretary of the exhibition; Mr. Frederic C. Penfield, of Hartford, chief of general staff; Mr. Rufus M. Smith, of Philadelphia, chief of installation; Mr. John Sartain, of Philadelphia, chief of department of fine arts; Mr. Vincent A. Applin, of London, secretary of the association; Mr. John Gibson, of London, architect; Mr. William Goldring, London, chief of the horticultural department. The burden of the work of organization and preparation has fallen upon Messrs. Whitley, Landreth, Speed and Applin; but at this time, when they see their labors bearing such abundant fruit, they are content to have spent three years of their lives in so grand an undertaking.

"On our side, we are happy to state, the organizers of the American Exhibition have been met with friendly and hospitable co-operation by a large body of more than a thousand Englishmen, among whom are many noblemen and gentlemen of position and influence, who have formed a council to devise means of giving a signal welcome to our American visitors, and to promote the success of this grand undertaking. Its unique and novel character, with the extraordinary scale on which it is designed, and the energy and capacity of its managers, bid fair to make an almost revolutionary epoch in the history of great exhibitions which commenced in 1851. And we heartily desire its success in every way, hoping above all that it will have the good effect of increasing popular acquaintance with that vast country, and with that mighty nation of English race in the United States of America, whose amazing growth and splendid prosperity should be admired, not with envy, but with pride and gladness, by all classes of people in the British Isles."

THE MAIN GALLERY OF THE MACHINERY PALACE OF THE FRENCH EXHIBITION OF 1889.

THE project of the machinery gallery of the Exhibition of 1889 has just been definitely approved and decided upon. The work, as regards the main gallery, was submitted to contract on the 24th of March. This important project has given rise to numerous studies that do the greatest honor to all those who, under the able direction of Mr. Alphaud, have engaged in them, viz., to Mr. Dutort, architect of the Machinery Palace; to Mr. Contamin, who, with his great skill in such matters, has calculated and fixed upon the dimensions of all the metallic pieces; and to Messrs. Charton, assistant engineer in chief, Pierron, engineer, and Escaude, director of studies concerning the details of construction of the metallic pieces.

No hall has ever yet been constructed entirely of steel and of so large dimensions. It may be said that this structure will embody the entire progress made in the art of the engineer, and will show the entire world to what serviceable and economic uses steel can now be applied. It is one of the boldest of conceptions, and would of itself assure of the success of the exhibition.

The gallery, as a whole, will be rectangular in shape, and have a length of 1,387 feet and a width of 492—say a plane surface of 672,404 square feet. If to this we add the area of the projecting pavilions and galleries of the first story, we have a total superficies of 942,870 feet.

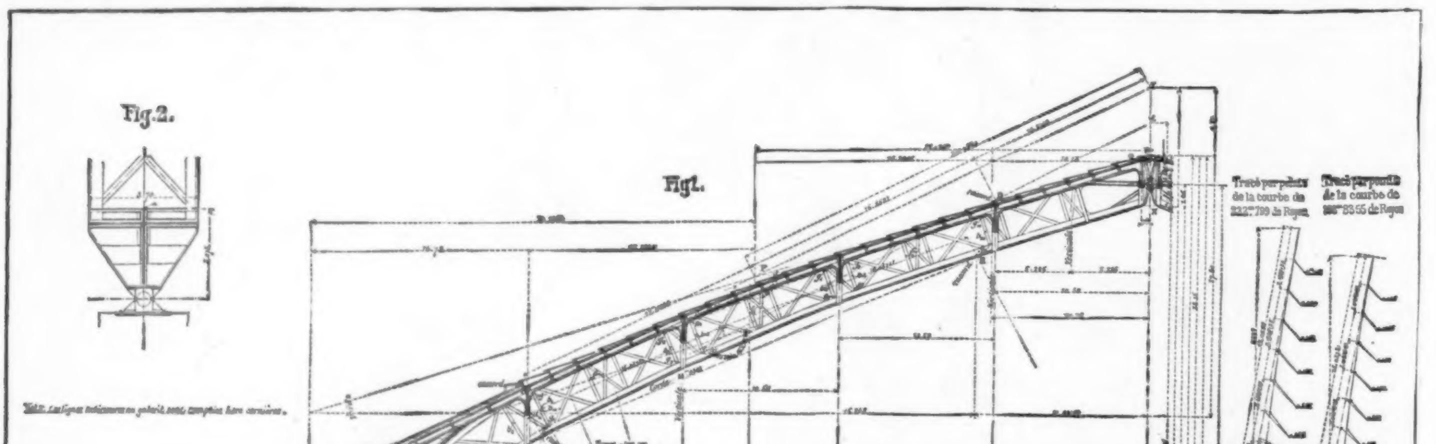


FIG. 1.—General Elevation of one of the Trusses (Scale, 1-200). FIG. 2.—Details of Lower Pivot (Scale, 1-100).

PLATE I.—MACHINERY PALACE OF THE PARIS EXHIBITION OF 1889.

est Earl's Court Station, where will be located 'Buffalo Bill's' Wild West Exhibition. The preparations for the reception of this unique entertainment have been very extensive. They were made under the supervision of Major J. M. Burke, the general manager of the 'Wild West.' The track is over one-third of a mile in circumference, and within this is the arena. It is flanked by a grand stand filled with seats and boxes, which will accommodate twenty thousand persons. Standing room under shelter is provided for over ten thousand more, and this, with the spectators in the open, will give a good view of the entertainment to about forty thousand people. A large hill has been thrown up of earth and rocks; and on this, amid a grove of newly planted trees, will be the encampment of the Indians, the 'cow-boys,' and scouts. At the other side of the grounds are extensive stables for the Broncho horses and mules, and a corral for the buffaloes, antelopes, elk, and other wild animals. This remarkable exhibition, the 'Wild West,' has created a furor in America, and the reason is easy to understand. It is not a circus, nor indeed is it acting at all, in a theatrical sense; but an exact reproduction of daily scenes in frontier life, as experienced and enacted by the very people who now form the 'Wild West' Company. It comprises Indian life, 'cow-boy' life, Indian fighting and burning Indian villages, lassoing and breaking in wild horses, shooting, feats of strength, and border athletic games and sports. It could only be possible for such a remarkable undertaking to be carried out by a remarkable man; and the Hon W. F. Cody, known as 'Buffalo Bill,' guide, scout, hunter, trapper, Indian fighter, and legislator, *is* a remarkable man. He is a perfect horseman, an unerring shot, a man of magnificent presence and physique, ignorant of the meaning of fear or fatigue. His life is a history of hairbreadth

The central part will be 362 feet in width from axis to axis. It will consist of nineteen bays, to wit: Two at the ends, measuring 83 feet; sixteen intermediate ones of 70 feet; and a central one of 76 feet. There will be no intermediate point of support. The trusses will cross the space of 362 feet without tie rods. The largest span of this kind that exists, as far as we know, is to be found in the hall of the Saint Pancras Station, London, where the span is 239 feet. Here the bases of the trusses are connected by tie rods placed beneath the flooring.

The trusses, which will be all alike, will present some very peculiar and extremely ingenious arrangements, which we shall before long describe and illustrate in detail. We shall be content just now to state that the trusses will consist of two arches resting at their bases and apices upon pivots, and that the roof pieces connecting them will be situated in vertical planes and not at right angles with the profile of the truss. The maximum height from the ground to the axis of the upper pivot will be 147 5 feet. To give an idea of such an elevation, we may compare it with the Vendome column, which is 145 feet in height.

Despite these exceptional dimensions, Mr. Contamin has succeeded, while observing the indispensable measures of prudence and security, in reducing the weight of the trusses, etc., to its extreme limit. The total weight will not exceed twenty-four pounds per square foot—a very remarkable result. We may recall the fact, by the way, that the metallic framework of the machinery gallery of the Exhibition of 1867 weighed thirty-four pounds to the square foot, and that of the Exhibition of 1878 thirty pounds.

These weights are not absolutely comparable, since the arrangements of the galleries were not the same; but it appears, nevertheless, that with the use of steel,

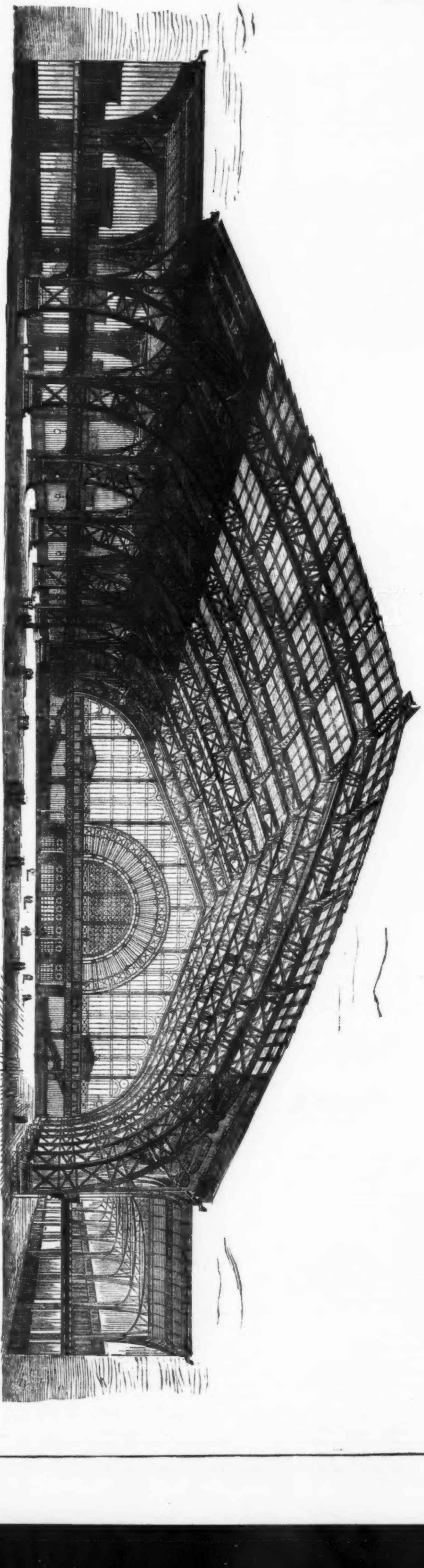


PLATE II.—MACHINERY PALACE OF THE PARIS EXHIBITION OF 1889.

the price of which is scarcely any higher now than that of iron, we are reaching much more economical results.

The Machinery Palace will consist of the main gallery, of which we have just spoken, and of annex galleries fifty-six feet in width, with the first story connected by broad stairs. It will be connected with the galleries of the various sections, in the principal axis of the Champ de Mars, by a central pavilion 98×98 feet.

The covering of the aisles and lower parts of the main gallery will be zinc. The remainder of the central portion will be covered with striated glass ¼ inch in thickness.

Notwithstanding the difficulties in the way of construction, especially in the way of laying the foundations, the estimated cost is but about three dollars per superficial foot.

The general decoration will be very simple. The architect will endeavor to give the structure a utilitarian character that does not exclude originality, and without any loss of artistic appearance.

The accompanying engraving (Plate II.) gives a perspective view of the main and lateral galleries.

The use of steel in the construction of this imposing building will be the first application of that material in a work of so great an importance. We doubt not that this proof of confidence accorded by our great engineers to a metal which, even to-day, is admitted with a certain fear by many of our builders, will happily contribute to increase the application of steel in our structures, and consequently to give a desirable impulse to its manufacture in our metallurgical works.

The 362¾ foot truss, like all bold works, has met with numerous partisans who have understood the true end of it; and it has also found many, and among them some of our most eminent architects and engineers, who have opposed the idea of erecting an immense hall with a span of 362¾ feet and a height of 148 feet for the reception of machines, which, as a general thing, have quite small vertical dimensions.

To meet this objection, it may be answered that the Machinery Palace is not only designed to contain all the marvels of mechanical construction due to modern science, but also (and this is not its least worthy aim) to show the entire world the power of the present French industry and the progress that has been made in the art of building with metal—a progress due in the main to our engineers of the Central School.

The main gallery of the Machinery Palace will form an immense rectangle 1,378 feet in length by 374 in width. Along two of the sides of this will extend the lateral galleries, that are very distinctly shown in the engraving.

The lattice girder that will support the flooring of these galleries, and which will surround the entire main hall, will produce a decorative effect of the happiest kind.

The entire space beneath the upper galleries will be free, the only points of support being taken upon the trusses themselves.

The general decoration will be a consequence of the construction itself, that is to say, it will be of the simplest character, without any false artifice, and will allow the spectator to clearly read the *motif* of every part.

The mounting of the trusses will begin on the 1st of July. On this occasion there is some talk of getting up a fete to replace the one designed to celebrate the breaking of the ground, and which was to have occurred when the work was begun.

Numerous studies are now being made of the system of lighting to be adopted. The magnificent electric light plants that have been established in recent times, and the progress that is being made every day, give reason for the belief that our engineers will emulate one another, and will in a large measure co-operate in the success of one of the most remarkable works of the Exhibition of 1889.—*Le Genie Civil.*

ON DEATH BY ELECTRICITY.

By M. D'ARSONVAL.

I HAVE just been performing a number of experiments with such electrical machines as are employed in the industries, with the view of determining under what conditions *intensities* and *potentials* may become dangerous. In a preceding communication I have already established the fact that what is truly dangerous when these machines are used is the *extra current* that occurs at the moment the current is broken, and in order to annul this extra current, I proposed to interpose a series of volta-meters containing acidulated water along the conducting wire.

The new arrangement that I now employ is at once more simple and efficient. It consists of a V-shaped tube made of an insulating substance. This tube, after being filled with mercury, is interposed in the main current. In order to close the latter, it is only necessary to turn a cock which is maneuvered like the cock of a gas pipe. In this way the machine is unprimed without its being able to give an extra current spark.

I also make use of another arrangement, and that is a glass tube filled with mercury and dipping into a reservoir containing the same substance. This tube is provided with a ground stopper that not only permits of suppressing the extra current, but also of interposing any sort of resistance in the circuit.

The practical conclusion to be drawn from these experiments is that the dangerous potentials of continuous currents do not begin till after 500 volts.

With alternating current machines it is the abrupt variations in the potentials that constitute the danger and give the paralyzing shock. It must not be forgotten, besides, that it is only necessary to touch one of the wires to get a discharge. The electromotive force of these machines should not exceed 60 volts.

It is of interest to state that the mechanism of death varies with the nature of the electricity employed. Thus, with the extra current or with alternating currents, there is no anatomical lesion, and the patient can usually be brought back to life through the practice of artificial respiration. The discharges of static electricity from batteries, on the contrary, cause a disorganization of the tissues that renders fruitless all attempts to restore life.—*Revue Internat. de l'Electricité.*

PROGRESS OF ELECTRIC RAILROADS.

To the Editor of the Railroad Gazette:

With electricity there is a remarkable flexibility of application and range of choice as to method. The car can carry its own power in storage batteries; the current conductors may be put out of sight in conduits; a third rail can be placed on any existing track; or the car may depend for current upon an overhead wire with contact trolley or brush; and all of these can be used together, if necessary, on one road. I have been on street railways where each of these plans is exemplified, and have found all practicable and operative. The motor can be put anywhere, even on the roof, and can be geared up in a dozen different ways. The average recovery of power is easily 60 to 65 per cent., and in every case the current required is exactly proportionate, at the minute, to the work being done. A first class horse car costing $1,200 will, with an electric motor, cost from $2,000 to $2,250, but the horse car road has from 6 to 12 horses per car, the horses costing about $125 to $150 apiece. The cost of the electric conductors is more than offset by the wear and tear of a horse track. The central station electric plant will, in many cases, be more than paid for by the economy in real estate, and it can be put anywhere along the line or near it. It can also, as it does now, supply electric light and power for general purposes.

Coming to the work actually done, it will be best to speak of the performances of the various motor companies, *seriatim*. The Daft Electric Light Co., of this city, has now had running at Baltimore for about two years a road using the third rail system, but now adopting the overhead wire. With an annual increase of passengers of over 75,000, the cost of electric power per car per day has been $4, as compared with the former cost for horses of $6.50 per car per day. The speed has been increased from 4 miles per hour with horses to 8 miles with motors. This road is 2 miles long, with grades up to 350 ft. per mile, and undulating throughout. The road has 3 motor cars and 3 passenger cars. Another road built on the Daft system is now in operation at Los Angeles, Cal., using the overhead wire. It runs 3 miles and is to be 2 miles longer. It has 4 motors and 4 cars, each of which has a carrying capacity of 40 persons, but has often carried twice that number. The road carried 14,982 passengers during February, and has taken as many as 1,500 in a single afternoon. The speed maintained is usually from 10 to 12 miles an hour. The Daft overhead system is also being employed on the Orange, N. J., Crosstown Railroad, where one motor car has been placed on the completed section of track. Another Daft road is being built at Pittsburg, by the Safety Electric Railway and Power Co., of New York. It is to cost $120,000, will have both overhead and conduit conductors, presents the slight difficulty of a 14 per cent. grade, and will go into operation this summer with 5 motor cars. The Daft system is also under contract for Mansfield, O., and Ithaca, N. Y.

The Van Depoele Electric Manufacturing Co., of Chicago, has a number of electric street railways in operation, presenting some novel features. The road of the Port Huron, Mich., Electric Street Railway Co. has 3 miles of track, one 15 h. p. motor running 3 cars, and two 10 h. p. motors, each running an independent car. The road crosses a swing bridge, but the overhead wire is so arranged that while the circuit is not broken when the bridge is open, the contact for the car is remade automatically as the bridge closes. The road is undergoing extension and increase of rolling stock. At Windsor, Ont.—a suburb of Detroit—a short road with 2 cars runs along the bank of the Detroit River. At Detroit is a road $1\frac{3}{4}$ miles long, with one motor car which, with its train, has traveled at the rate of over 25 miles an hour. The service is being increased. At Appleton, Wis., the Appleton street railway put the Van Depoele system in operation last year. The motive power is obtained from a 60 h. p. dynamo driven by a water wheel, and a double overhead conductor is in use. The initial rolling stock consisted of 5 cars with motors, but the plant is growing very rapidly. The road is $4\frac{1}{2}$ miles long, including 9 per cent. grades, some on sharp curves. The total cost for power for the 5 car service figures out at $1.50 per car per day.

At Scranton, Pa., the Scranton Suburban Railway Co. has over 2 miles of Van Depoele road running with great success. The rolling stock was 3 cars at the start, but is being largely increased. Overhead conductors are used, with little contact trolleys. Speed ranges from 6 to 15 miles an hour. Grades are up to 6 per cent. As on the Appleton road, handsome Pullman cars are in use. The power is furnished by the electric light station, where a 60 h. p. dynamo is installed. The total charge for power is $9 per day of 16 to 17 hours, but as the dynamo can easily operate from 8 to 10 cars, the item of $3 per day per car is excessive. It will, in almost every case of electric railways with current conductors, be safe to estimate from $2.50 to $3 per day per car as the total cost of power, that being a liberal basis of calculation.

At Montgomery, Ala., the Van Depoele system was tried on a road $1\frac{1}{2}$ miles long, and is now being applied to the whole network, with overhead conductors throughout. The total length of track thus equipped is over 11 miles, consisting of a main trunk road with four branches. Brill cars are to be used, with 18 motors. One of the owners of the road told me recently that he had found a saving with electricity of from 30 to 40 per cent., and he expected much better results over the whole system.

The Van Depoele Co. has contracts now being executed for roads at Lima, O., and Binghamton, N. Y. The latter road $4\frac{1}{2}$ miles long, will be equipped with 3 cars with 10 h. p. motors, 4 cars with 15 h. p. motors and 1 car with a 20 h. p. motor. The Lima road is 3 miles long and will have 6 cars.

The Denver, Col., Tramway Co. has $3\frac{1}{2}$ miles of road equipped with the Short-Nesmith system, and has 7 cars in operation, making an average speed of 6 miles an hour. The conduit in use has a $\frac{5}{8}$ in. slot. The track crosses five steam railway tracks, eight horse car tracks, and a bridge 200 ft. long. The current lights the cars and rings the gongs.

At Detroit, Mich., the Detroit Electrical Works are operating on the Highland Park road 2 cars, 13 hours per day, using not to exceed 900 lb. of coal, at $1.60 a ton, bringing the cost of fuel somewhat under 80 cents, or 40 cents per day per car. The Fisher system is in use. A speed is maintained of about 15 miles an hour with a load of 30 passengers to the car. The motors, weighing 1,100 lb., are suspended between the trucks. The road is 3 miles in length, but is now being extended half a mile further. It is operated by two engineers and a motor man, who also acts as conductor, for each car. A simple conduit system is in use, a light rail, over which a phosphor-bronze contact wheel travels, being sunken between the rails under grooved planks. The system is now to be applied in Pittsburg, where it is under contract for a road about one mile long, beginning with 2 cars.

The Henry Electric Railway Co., Kansas City, has equipped with overhead conductor a double track road starting from East Fifth Street, and proposes to run two-car trains on it. The same company reports that it is also equipping a 9 mile road in the suburbs of San Diego, Cal., where very high speed will be attained.

The Union Electric Co., of Philadelphia, has a 2 mile road on the Schlesinger system, with conduit, on Ridge Avenue, Philadelphia. Just at present, however, the company is busy on the construction of mining roads. It is now executing a contract for a large mining company, the road, wholly in the mine, being 6,000 ft. long. The electric locomotive will haul from 15 to 20 loaded cars. Similar equipment is being contracted for on two other mine roads, and in one of these cases, by the way, an electric power transmission of 400 h. p. over three quarters of a mile is contemplated.

The Sprague Electric Railway and Motor Co., of New York, has built a road for the East Boston Sugar Refinery Co., running from the water front up into the refinery, to convey sugar in bulk. An overhead conductor is used, with contact trolley and flexible connector. The cars will have a carrying capacity of $4\frac{1}{2}$ tons each. The dynamo supplying current for the road during the day will feed incandescent lamps at night. The Sprague system has also been adopted by the Union Street Railroad of St. Joseph, Mo. At least 20 cars will constitute the preliminary equipment. Current from the electric mains will also light the cars, and speed up to 12 miles an hour is to be reached. The Sprague Co. has also been making some important tests with storage batteries on street cars, with remarkably good results, under the supervision of one of the best known firms of street railway engineers in the world. One such car has been ordered for a Boston road, and though the experiments have but recently been finished, the company has had applications from well nigh a hundred roads for estimates looking to the use of the storage system. A very large number of estimates have also been requested and made for roads with the direct current system, using overhead conductors or shallow conduits. I have had an opportunity of looking through the estimates and find them to cover roads all over the Union, sometimes two or three in one city.

The Bentley-Knight Electric Railway Co.'s conduit system is to be used in New York City by the North and East River Railway Co., whose tracks will run through Fulton Street, across the city, to Wall and Pavonia ferries. The Bentley-Knight system, which has been specially worked out with a view to use in large cities, was demonstrated first on a road in Cleveland, O., and is now to be seen on a track at the Rhode Island Locomotive Works, Providence. Its introduction into New York renders its details very interesting, but they cannot all be given. The nature of the thoroughfare and the heavy traffic on it calls for the best construction. The grades run up to 1 in 10. The conduit to be used is only $13\frac{1}{2}$ inches deep, and $25\frac{1}{2}$ inches wide, over all, and the contact plows are so devised that in any case of necessity they can be pulled clean out of the slot at a second's notice. The road will go into operation with 20 motor cars, and the work of preparation is now going on busily, all the contracts having been made. As the franchise expressly stipulates the use of this system, there is no reason to doubt that it will go into operation this summer, probably by August 1.

The Bentley-Knight Co. has also closed a contract this month with the Observatory Hill Passenger Railway Co., Allegheny City, Pa., and hopes to fill it by the end of July. In this road it supplies about 1,200 ft. of double track conduit, and about the same length of single track conduit; and then the conductors go overhead and run out some three miles in the suburbs. As soon as the conduit proves satisfactory, this road will be extended across the river into Pittsburg. It is a really tough job, as there is a maximum grade of 10 per cent. to climb carrying a full load, Broadway cars, at a rate on that stretch of not less than four miles an hour.

I ought not to omit mention here of the fact that this is the system in view for the New York Underground Railway, which, if the plans are carried out, will be a magnificent piece of engineering all round. The motors intended for this are of 400 h. p., capable of making 50 miles an hour, and weighing 48,000 lb.

The Julien Electric Co., of New York, has made a demonstration with its storage battery and motor on the Eighth Avenue road in this city. I have, myself, had the pleasure of trying the car, which was very smooth, steady, and rapid in operation. The system is now also being tried in St. Louis, and bids fair to be adopted in a great many places. With the storage batteries of the Electrical Accumulator Co., of New York, driving such motors as the Sprague, some excellent results have also been attained. As far as can now be learned, running street cars by electric storage will not cost more than $4 to $5 per day, on regular city schedule and traffic, as compared with $6.50 to $7.50 for horses. The cost of the cells is still high, but comes within the cost of horses—from 6 to 12 per car—and will, in my opinion, be materially reduced by improvements in the batteries inside of a twelvemonth. With the storage system, no conductors or conduits are needed.

There are some new systems awaiting trial, such as the Ries, Bidwell, Edgerton, Field, and others, embodying some very notable points of excellence, but it would take too much space to discuss them now, as it would the experiments made, and yet to be made, on the New York elevated roads, or the various roads shown at exhibitions and other like resorts during the last four or five years, and having to their credit about 500,000 passengers carried in safety and comfort. I must also pass by such special systems, dependent on electricity, as the Enos suspended car road, which is to be adopted at Los Angeles, Cal., and the Chandler aerial transportation road. I must close simply with an enumeration of the roads and places about to adopt electricity. At Ansonia, Conn., an electric road, $3\frac{1}{2}$ miles long, from Derby to Birmingham and Ansonia, using overhead wire, has been contracted for. It will be used for both freight and passengers, and power to drive the dynamo will be taken from the Housatonic dam. At Newton, Mass., a road is to be built by a company already formed; one is proposed for Worcester, Mass. At Brookline, Mass., two will soon be in operation, and one each is in view at Bangor and Biddeford, Me. Two roads are contemplated in Brooklyn, one at Coney Island, and one at Rockaway. Pelham Park, N. Y., is to have a road this summer, and Asbury Park, N. J., is advertising for bids on another. Franchises are asked for a road in Jersey City and Bayonne; and Plainfield, N. J., is also wanting a road. In Pennsylvania, Scranton, with one successful road, is to have another, and probably two. A road is to be built from Carbondale to Jermyn, 4 miles. In Reading, the Perkiomen Avenue Company proposes to adopt electricity. Harrisburg is to have a road, and it looks as though before the end of the year Pittsburg will have half a dozen. Down South steps have been taken to construct new electric roads, or adopt the system on old roads in Jacksonville, Fla.; Pensacola, Fla.; Birmingham, Ala.; Selma, Ala.; Atlanta, Ga.; and Fort Smith, Ark. Among roads spoken of in Ohio are several at Cincinnati, Cleveland, Tiffin, and other places. Wichita, Kan., is proposing to adopt electricity for its street cars. Lincoln, Neb., has formed a company to operate an electric railway from the business part of the town to the stock yards. In San Francisco a road is to be built on Fillmore Street hill, and roads are also wanted at San Jose and Riverside, San Bernardino County. If I were at liberty to do so, I could add to the above list about fifty names of places where, from present indications and movements, it is safe to say that electric roads will be running within a year.—*T. C. Martin, in Railroad Gazette.*

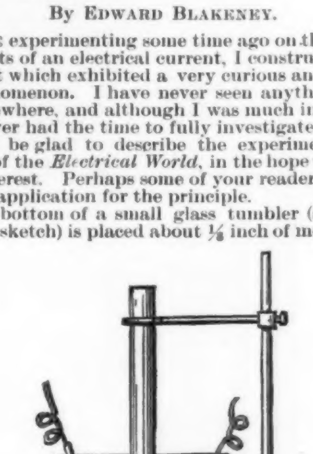
SURFACE TENSION OF LIQUIDS UNDER THE INFLUENCE OF THE ELECTRIC CURRENT.

By EDWARD BLAKENEY.

WHILE experimenting some time ago on the mechanical effects of an electrical current, I constructed an instrument which exhibited a very curious and interesting phenomenon. I have never seen anything of the kind elsewhere, and although I was much interested, I have never had the time to fully investigate it.

I shall be glad to describe the experiment to the readers of the *Electrical World*, in the hope that it will be of interest. Perhaps some of your readers may find a useful application for the principle.

In the bottom of a small glass tumbler (see accompanying sketch) is placed about $\frac{1}{8}$ inch of mercury. A



SURFACE TENSION OF LIQUIDS.

glass tube of $\frac{1}{2}$ inch internal diameter is suspended vertically in the center of the tumbler, with its lower end dipping into the mercury, but not quite touching the bottom of the tumbler.

A punctured copper disk is slid down over the tube. This disk serves as one of the electrodes, the mercury serves as the other. The tumbler is then filled with water.

When, now, a battery of two or three cells is connected to the terminals, the mercury is seen to be somewhat agitated, and at the same time the water begins to rise in the tube. If the latter be not too high, the water at last overflows and the action continues; but if the tube be over two or three inches high, there is a point reached where the water will rise no higher. This, undoubtedly, is the point of equilibrium between the weight of the water and the force which is acting upon it.

It will be noticed that, in order to ascend the tube, the water must first find its way under the mercury. So far as I investigated the matter, it appeared to me that the mercury took on a sort of vortex motion, drawing the water down at the sides and expelling it in the center, thus filling the tube.

When the action is continuous, the instrument might properly be called a vortex electrical pump. —*Elec. World.*

REGENERATING LECLANCHE CELLS.—M. Eugene Alliot, of Chateaurenault, employs a battery of eight Leclanche elements, with which he occasionally lights up a couple of small glow lamps for a few minutes at a time. Owing to the rapid polarization of the battery, it is, of course, impossible to get a full light for more than a few minutes. It, however, occurred to M. Alliot to try "to regenerate the zinc and the dioxide of manganese" by means of a reversed current. By sending the current from a small dynamo through the cells once a week, for only a few minutes at a time, it was found that the Leclanches did not tend to polarize when feeding the lamps nearly as quickly as before. It will, however, scarcely be admitted that the zinc has been "regenerated" by this process, although, no doubt, the depolarizing effect of the reverse current re-

sults in restoring the cells to the most favorable condition for working, and where a current of sufficient E.M.F. is already available the hint may sometimes be worth taking.—*Electrical Review.*

HYDRAULIC RIVETING MACHINE.

FIG. 1 represents a hydraulic riveting machine invented by Mr. L. Delaloe and greatly improved by Mr.

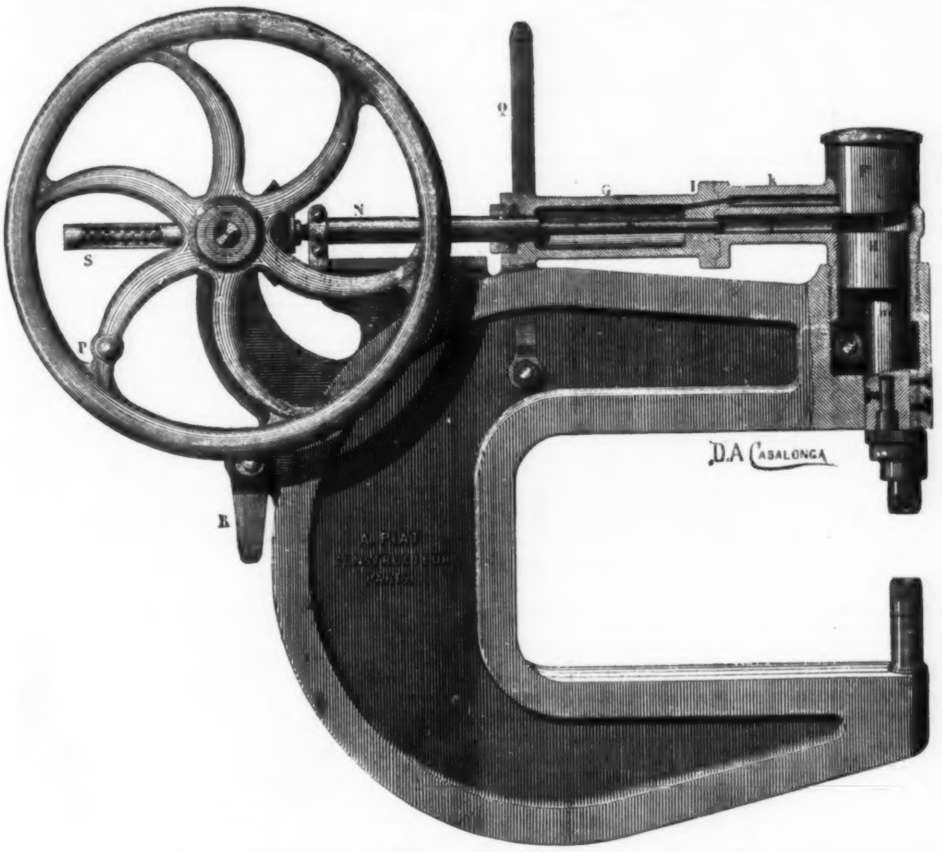


FIG. 1.—IMPROVED RIVETING MACHINE.

A. Piat. Fig. 2 shows a vertical section through the axis of the clack valve, B, as well as through the cylinder, F; and Fig. 3 gives a plan view. Figs. 4, 5, and 6 show

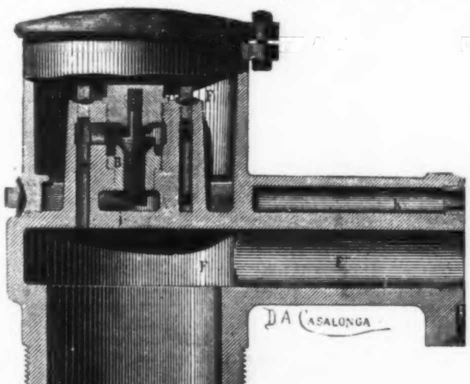


FIG. 2.

FIG. 3.

various sections of the general distribution in the reservoir, F'.

The cylinder, F, with reservoir, F', and elbow, F'', and the cylinder, G, having been first filled with a sufficient quantity of water and glycerine, and the piston, H, being at the end of its stroke, the following are the successive maneuvers to be effected as soon as a rivet has been put in place: In the first place, through the pinion, M, whose axle is provided with a winch, and which gears with the rack, *m*, the piston, H, followed by water coming from the reservoir, F', through the seat of the valve, B, descends until the hammers come into contact with the rivet and slightly spread it. As at this moment the direct stress exerted by hand, through the pinion, M, is insufficient to continue the spreading, the handwheel, P, is set in action by the operator. The bevel wheels (one of which has a threaded center serving as a nut to the screw, S, of

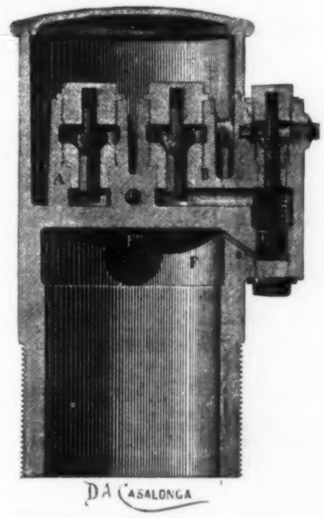


FIG. 4.

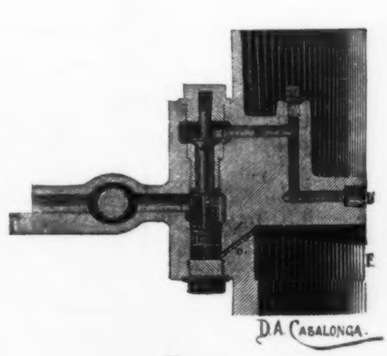


FIG. 5.

which the piston, N N', forms part) thrust the piston, N N', forward so as to compress the confined liquid and force it against the piston, H. This forcing of the liquid occurs, on the one hand, directly through the pipe, F'', into which the part N' of the piston, N, enters, and, on the other hand (by reason of the forcing effected in the cylinder, G, by the piston, N), through the conduit, *l*, the channel, *k*, the conduit, *b*, the seat of the valve, A, which lifts, and finally through the conduit, *r*. The valves, C B, are kept closed by the pressure coming, on the one hand, from the channel, *k*, through the branch, *b'b'*, and, on the other, from the cylinder, F, through the conduit, *a*. As soon as the pressure in the cylinder, F, has reached a certain point, which has been determined beforehand, the small piston, D, which is held by the spring, *l*, and the cylinder of which communicates with F through a small channel, *o*, rises. Its rod lifts the clack valve, C, and thus gives passage, toward the reservoir, F', to the water forced from the cylinder, G, by the piston, N.

After this, the cylinder, F, no longer receives any water but that forced through the part N' of the piston, N. The velocity of the piston, H, becomes notably diminished, but the stress that it exerts increases so much the more, and it is due to this that it finishes the spreading of the rivet.

After this operation is effected, the clack valve, B, having been first lifted by means of the handle, J, and tappet, *j*, the piston, H, is raised through the action of the pinion, M, and the water passes to the reservoir, F, through the conduit, *a*, and the seat of the valve, B. When once the piston, H, is at the end of its stroke, the piston, N N', is carried back by the screw, S, which, through bevel gearing, is actuated by the handwheel, P. The water sucked by the piston, N, into the cylin-

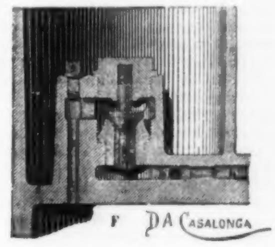


FIG. 6.

der, G, returns thither from the reservoir, F', through the seat of the valve, C, the branch, *b'b'*, the channel K, and the conduit, *o*. The water sucked by the part N' of the piston, N, into the cylinder, F F'', returns thither from the same reservoir, F', through the seat of the valve, B, and the conduit, *a*. The apparatus is thus ready to spread another rivet or to do chiseling or punching, according to the tools fixed to the bottom of the piston, H, and the counterpart, K.

The machine can be suspended by a chain through the intermedium of the stirrup, Q, and operate in the position figured, or through the stirrup, R, so as to operate vertically. It can likewise be made stationary, and the handwheel be replaced by a mechanical arrangement for changing direction actuated by a motor.

The machine, which is portable and easily managed, is applicable to riveting on both a small and large scale. One man can effect the spreading of the largest rivet in 8 or 10 seconds, through the handwheel, and obtain a pressure of about four thousand pounds to the square inch. The hand machine is capable of spreading from 1,000 to 1,200 rivets per day.—*Chronique Industrielle.*

A NEW DOUGH DIVIDING MACHINE.

HITHERTO loaf bread, or rather the dough that was to be baked into loaves of bread, has usually been cut to the required size and weighed out by hand. Supposing, for instance, it was necessary to bake a batch of 360 quartern loaves, the dough would be received from the kneading trough, whether mechanical or otherwise, and the foreman would set so many men to work to cut and weigh out 360 pieces of dough of 2 lb. and, say, 3 oz. each. That amount of labor would have to be

NEW DOUGH DIVIDER.

gone through before the staff of the bakery could proceed with the operations of moulding the loaves to the requisite shape and of putting them in the oven. Now, a machine has recently been introduced which would allow of those 360 pieces of dough being cut and weighed out in fifteen rapid and successive operations.

The illustration and following description will enable our readers to form some idea of the construction and working of this machine, which, it should be noted, is based on the well-known law of physics that equal mass in equal space gives equal weight.

The action of the machine is as follows: A mass of dough is weighed off, equal in weight to the total number of loaves which the machine divides. Thus, if a 4 dozen machine is used, and each loaf is wanted to weigh 2 lb. 3 oz. in dough, a mass is required=48×2 lb. 3 oz., or 105 lb. This mass of dough is placed in a box sliding under the machine on two parallel bars, as shown; the box is pushed home to its position, fixed by two stops; a handle is drawn, causing a large flat plate, which exactly fits the inside of the box, to descend; this plate presses the dough in box out perfectly level, and when this is done, a number of knives or blades come down through the slots in the plate and divide the dough into 48 pieces of exactly equal weight; the plate is then raised, the blades withdrawn, the machine stops, and the box is pulled out to be emptied, ready for another charge, which meanwhile has been scaled off.

We understand that from the start the machine is entirely automatic in its action, reversing and stopping itself and requiring no special attention. It is also claimed that the divider will automatically adapt itself to deal with stiff or moderately slack dough, and that its action can be so varied as to divide loaves of any weight from half a pound to two pounds and a half. This machine can only be worked by power, but on the other hand, its consumption of motive force is very moderate, if, as we are assured, it can be driven by 1 to 2 horse power, according to capacity. The advantages to be derived from the use of this loaf-dough divider seem to be very considerable. In the first place, it is essentially a labor saving machine, as may at once be realized from the example given at the beginning of this article of the dividing and weighing of the 360 pieces of dough. It is indeed claimed that with this machine two operatives, without any special training, can do the work of six skilled bakers. Then again the whole operation of weighing, or, as it is termed in the bake house, "scaling," is said to be greatly simplified. Thus for any desired variation in the weight of bread, only one set of weight need be changed.

The greatest accuracy is claimed for this divider as regards the work of weighing, and this, of course, means a great saving of material in a large establishment. Messrs. Thomson Bros., of the Armour Street Bakery, Glasgow, in whose bake house the machine has been at work for some months, report that the greatest variation they have found in the division of the dough did not exceed half an ounce, and that not above once in a hundred cuttings.

Last, but not least, it is claimed for the loaf-dough divider, that as it delivers each loaf in one solid mass of dough, the necessity for adding small lumps of dough to make up weight, which is inevitable in hand scaling, ceases to exist, and this in itself is no small advantage, inasmuch as those makeweights are liable to drop off and spoil the symmetry of the moulder's work. Again, it is urged that each loaf being pressed by the cutter into one compact piece is the more easily laid, and takes, in bake house parlance, a better "skin."—*Miller.*

SPHERE AND ROLLER MECHANISM.

It is often necessary, in constructing machinery, to devise some means of obtaining easily a variable speed, and many methods of doing this are in existence. The use of a revolving sphere as an intermediary in cases of this kind was suggested a few years ago by Professor Hele Shaw, of University College, Liverpool, when the scheme was discussed at some length. At present, we are not concerned so much with the theory of his invention as with its practical construction. But it will not be without its advantages if the main features are briefly examined from a practical point of view. If a sphere is held at its axis by any means, and revolved, the speed due to the revolution of any point on its surface is greater or less according to the distance the point is from the axis. Thus, if motion is communicated to a roller frictionally in contact with the sphere, the speed of the roller will vary in exact proportion to its distance from the axis of the sphere. This is so clear that it scarcely needs further elucidation. The mechanism about to be described in its main features embodies the idea just set out, the sphere being held axially by the two revolving rollers, carried in a suitable frame, and being driven by a friction roller fixed on a shaft, the power being taken off through a second friction roller. The method of forming the axis by two rollers permits of an easy adjustment of the axis when required, thus needing very little employment of power, and allowing a delicate range of variation of speed.

A practical application has been made, by Edward Shaw, of Bristol, to hoisting machinery, the latest form being that of a sack hoist, one of which was at work in the Liverpool Exhibition of last year.

This is illustrated in Figs. 1, 2, and 3, which are respectively a side elevation, a plan partially in section, and an end view also partially in section. There are two spheres employed in this machine, which are so placed as to come in contact with each other. The driving of the spheres is effected as shown, by means of a small barrel having frictional surfaces formed on the flanges, so that each flange drives one sphere. On the chain barrel, two similar surfaces are formed, and the spheres are kept in close contact with both the driving and the driven surfaces by the action of the frame, which is arranged like a spring, and which can be drawn up by means of the bolt and nut shown in the illustration.

The axial rollers, AA, of which there are two to each sphere, are carried in suitable frames, which are so connected by steel bands that, when one frame is turned, the other is also moved symmetrically to the same extent. The driving barrel is cast in one piece with the hollow shaft, on the end of which a friction clutch, acting as driving pulley, is fastened. The loose part of the friction clutch is withdrawn by means of a rod, B, having a square thread on its end. The end of the barrel shaft is also screwed as shown, and is provided with a nut which can travel longitudinally, the length of traverse being regulated by the lock nuts. To the nut named a rod is connected, coupled at its other end to the bell lever, C, which operates the catch, D. By this means, C is brought in contact with an arm, E, projecting from a nut fitted on the rod, B. So long as the nut and arm are allowed to revolve, winding goes on. But when the motion of these is arrested, the rod, B, slides longitudinally, and the friction clutch is disengaged.

The chief advantage derived from this arrangement is that any grinding of the spheres is prevented, the motion of the axial rollers being simply used to vary the speed of the driven barrel, that of the driver being, of course, constant. It is stated that, in a lift made on this principle, which has been in constant use in Mr. Shaw's works for twelve months, no wear of the spheres is perceptible. The chief objection to the use of all frictional appliances is, of course, the loss of power arising from friction in the bearings. To some extent this is provided for by the provision of special bearings, in which lubrication is at all times effectually carried out.

In order to set this matter at rest, Professor Shaw and his brother, Mr. Edward Shaw, carried out a series of experiments, in order to demonstrate the amount of power lost in the bearings. The experiments were conducted with various ratios of speeds between the driving and driven barrels, and it was found that when the ratio was 12 to 1 the mechanical efficiency was 40 to 50 per cent. and with a ratio of 4 to 1 it was 73 per cent. The tests were conducted with special devices, to insure accuracy, and it was found that when hard surfaces of cast iron were used, driving could be carried out with very high pressures on the spheres, without experiencing any serious loss of power through friction.

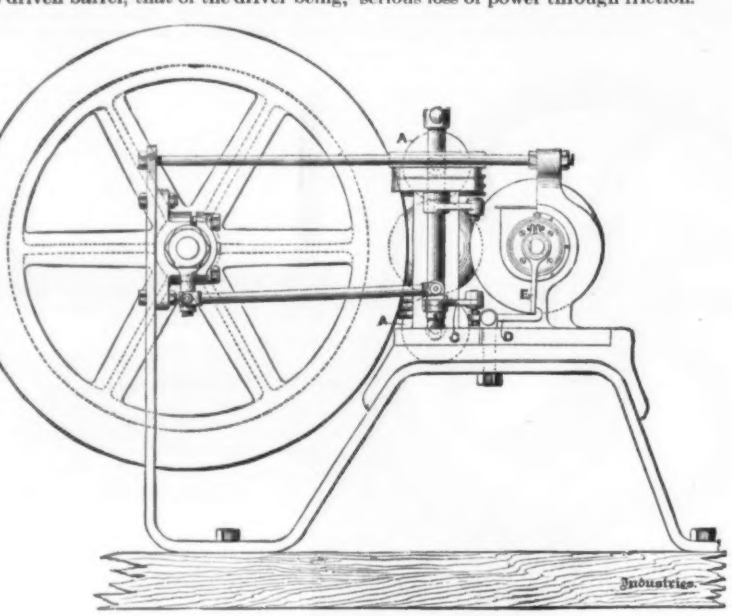


Fig. 1.—SIDE ELEVATION.

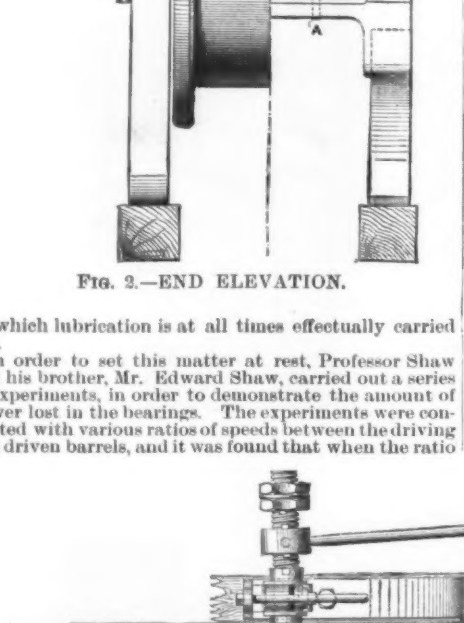


Fig. 2.—END ELEVATION.

Another point of importance is, that when the frictional surface of the rollers, which is in contact with the spheres, is reduced to $\frac{1}{8}$ in., the result obtained is better than when a larger surface is used. A full account of these experiments, with plates showing graphically, by means of curves, the very interesting results obtained on the subject of rolling friction, has been ordered by the General Committee of the British Association to be printed *in extenso* among the reports of the meeting held at Birmingham last autumn. The hoist which has been described performed its duty admirably, and could, by altering the position of the axial rollers, lift at varying speeds, or be reversed for lowering, as desired.

On the whole, we think that the apparatus is worth a further and more extended trial and application to machines of a more important character. So far as hoisting is concerned, it does not often matter whether the speed can be varied rapidly or not. But there are numerous cases, especially in connection with the mechanism of textile machinery, where some such motion is desirable.—*Industries.*

DR. WERNER SIEMENS' NEW ANEMOMETER.

By Dr. A. Koepsel.

At the exhibition of scientific instruments given in honor of the fifty-ninth meeting of German scientists and doctors (*Versammlung deutscher Naturforscher und Aertze*), among the numerous instruments of precision which the firm of Siemens & Halske sent to the exposition was an anemometer, entered by Dr. Werner Siemens, which rests upon a principle hitherto unused. In it the phenomenon of suction is used for measuring the force of the wind. Furthermore, with this apparatus the mean force of the wind for a given period can be registered, and also the direction of the wind can be determined, though it may vary every instant.

The apparatus is thus constructed: A measuring cylinder, C, is graduated in cubic centimeters, and is hermetically closed by a metallic plate, D. Through the latter are two apertures. Into one aperture is fitted a brass tube, S, with a fine drawn out end; into the other is cemented a siphon tube, H, bent twice at right angles. The leg which is inserted into the cylinder is provided with brass springs, which support a small lipped beaker, B. The other leg dips into a larger vessel containing petroleum, whose level is kept constant by a constant dripping of petroleum from a vessel, R, with a fine opening, situated above it, the excess of oil overflowing. This arrangement is more suitable than Mariotte's bottle, the bubbling action of

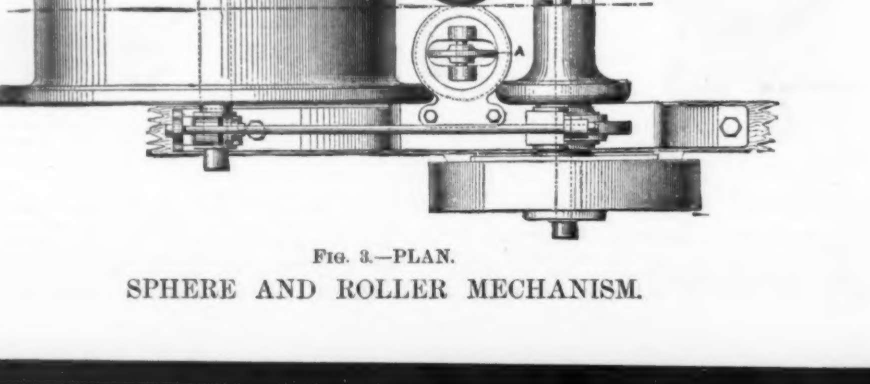


Fig. 3.—PLAN.

SPHERE AND ROLLER MECHANISM.

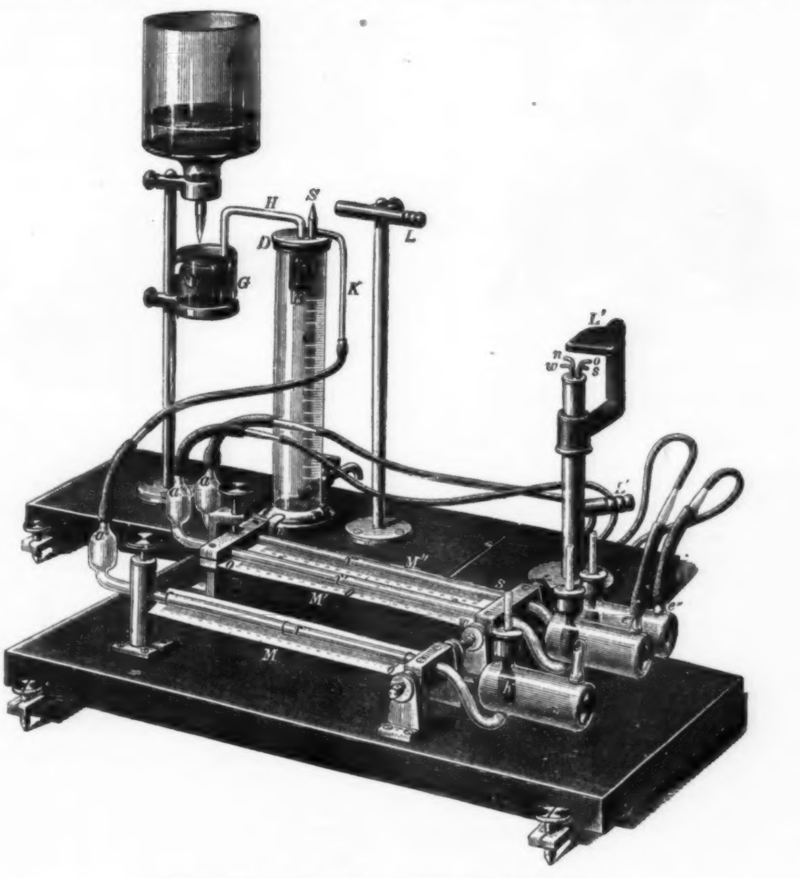
which, varying the capillary force, prevents the possibility of obtaining a constant level.

Petroleum is used as the liquid, because it drops better than water, and evaporates less than fluids perhaps otherwise available in most respects.

The pointed tube, S, by a branch, K, and India rubber tube, communicates with a manometer, M, whose graduated portion, *r*, is only slightly inclined from the horizontal. A wide glass vessel, *m*, is integral with it, which is filled with colored petroleum. An expanded plunger, *k*, that dips into it, can, by being raised or depressed, adjust the level to the zero point.

To set the apparatus at work, the air in the cylinder, C, is first exhausted by suction, in consequence of which the small beaker glass contained therein is filled. The level of liquid in the latter is now so adjusted by raising or lowering the vessel, G, that the least exhaustion of the air in the cylinder, C, will cause the liquid to drop into its bottom out of the beaker. If by means of a tube, L, placed alongside of and perpendicular to the jet, S, a stream of air is blown across the same, the fluid in consequence of the aspiration thus brought about drops from the lip of the beaker into the cylinder, and the volume of the fluid thus delivered gives the measure of the mean wind power. If, instead of the wide siphon tube, a capillary one is used to join the two vessels, the volume of fluid is no longer the measure of the mean wind power, but is proportioned to the sum of the pressures. By the same partial exhaustion the fluid in the manometer tube, *r*, is also drawn up to some determinate height, which, when it has attained equilibrium, admits of the force of the wind being read off by means of a specially graduated scale.

The apparatus for determining the direction of the wind comprises four tubes, *n*, *o*, *s*, *w*, bent at right angles, and whose openings are directed to the four



SIEMENS' NEW ANEMOMETER.

cardinal points of the compass. Each directly opposite pair are connected by India rubber tubes with the openings, *a'e' a''e''*, of the manometers, M' M'', arranged like the preceding one. The zero point of these lies in the middle of the tubes, *r'*, *r''*, and the four ends of the scale are marked with the initials of the four cardinal points of the compass. If the wind comes from a direction which one of the openings faces, a compression of air is produced in it accompanied by a rarefaction in the opposite one. The compression works on one end, the exhaustion on the other end, of one of the manometers; the level of the fluid is also forced from the zero point toward the end of the tube marked with the proper initial designating the direction of the wind. With regard to the two other openings at right angles to these, the wind produces an equal exhaustion at both, which, operating on both ends of the other manometer, does not at all affect the position of its column, which stays at zero. But a single reading of the apparatus gives also the intermediate directions of wind by the greater or less changes in the level of the fluid in both manometers.

For purposes of demonstration, this apparatus is provided with the adjustable tube, L', with wider opening to represent the wind, as well as the tube, L, of the registering apparatus, both of which are dispensed with in actual meteorological work. In conclusion it should be noted that Prof. v. Bezold first suggested the registration of the wind by the amount of fluid dropped under such conditions, and that in this apparatus the first attempt was made to carry out the suggestion.—*Zeitschrift fur Instrumentenkunde.*

A GOOD moth powder is made of ground hops one drachm, Scotch snuff two ounces, camphor gum one ounce, black pepper one ounce, cedar sawdust four ounces; mix thoroughly and strew among the furs and woolen to be protected.

COATING PAPER WITH GELATINE EMULSIONS.

THE Rev. R. W. Burbank, in the *Photo. Times*, relates the following practical directions for coating paper with sensitive argentic gelatino-bromide emulsions:

That there are difficulties in the process I freely admit, but I also know from experience that they can be overcome by any careful, cleanly manipulator; and I gladly give my experience for the benefit of all brother amateurs who may care to profit by it, assuring them that if they will follow my directions carefully and intelligently, they will have no difficulty in turning out finished prints of their own make, from beginning to end, which will meet the demands of the most exacting, and at a fraction of the cost of the commercial article. Will it awaken the enthusiasm of any lover of the art to be told that it is possible to produce prints of irreproachable purity in the whites and velvety softness in the blacks, at a cost not exceeding three cents a piece for the whole-plate size? Such, however, is about the cost of prints made by the method which I will now proceed to describe in every detail, that he who runs may read. I give the formula for the emulsion in *grains* to the ounce of water, as I believe that to be the only scientific method.

THE EMULSION.

NO. 1.

Gelatine (soft)	42½ grains.
Bromide of potassium	26 grains.
Water (distilled)	1 ounce.

NO. 2.

Nitrate of silver	32⅓ grains.
Water (distilled)	1 ounce.

Dissolve the bromide first, then add the gelatine, and dissolve by gentle heat (95 deg. to 100 deg. Fahr.); bring the silver solution to the same temperature, and add in a small stream to the gelatine solution, stirring vigorously, of course, in non-actinic light. Keep the mixed emulsion at a temperature of 105 deg. Fahr. for half an hour or an hour, according to the degree of sensitiveness required, previously adding one drop of nitric acid to every five ounces of emulsion. Allow it to set, squeeze through working canvas, and wash two hours in running water. In my own practice, I manage the washing easily enough by breaking the emulsion up into an earthen jar filled with cold water, and placed in my dark room sink. A tall lamp chimney, standing in the jar immediately under the tap, conducts the fresh water to the bottom of the jar, and keeps the finely divided emulsion in constant motion; a piece of muslin, laid over the top of the jar to prevent any of the emulsion running out, completes this simple, inexpensive, but efficient washing apparatus.

The washing completed, you are ready to melt and filter the emulsion preparatory to coating the paper. When melted, and before filtering, it is well to add of glycerine and alcohol each about one-tenth of the whole bulk of the emulsion, the glycerine preventing troublesome cockling of the paper as it dries, and the alcohol preventing air bubbles, and hastening the drying. This addition made and the emulsion filtered, you are ready to coat your paper, which may be coated just as it comes from the stock dealer, plain Saxe or Rives, or better still given a substratum of insoluble gelatine, made as follows:

Gelatine	1⅞ grains.
Water	1 ounce.

Dissolve and filter; then add 11 drops of a 1:50 filtered chrome alum solution. The paper is to be floated for half a minute on this solution, avoiding air bubbles, and then hung up to dry in a room free from dust. The purpose of this substratum is to secure additional brilliancy in the finished prints by keeping the emulsion isolated from the surface of the paper. If you are floating the whole sheet, now is the proper time to cut it to the size you wish to coat, but for anything less than 6½ × 8½ I would recommend cutting in double or quadruple sizes, 8 × 10 for 5 × 8 and 4 × 5 prints, as the paper is easily cut down after the emulsion is dry.

COATING.

Apparatus.—A stone, marble, or glass slab large enough to hold at least half a dozen glasses of the size paper you are coating, and most accurately leveled; a dozen or more pieces of glass of the same size as your paper; a porcelain or agate ware tray of the same size; a ruby lamp; a deep tray of a size to hold your jug of emulsion and the smaller tray; a spirit or kerosene lamp inclosed in a box suitably ventilated and protected against the egress of white light from the lamp inside (this is easily secured by punching holes around the top and bottom of a tin box of suitable size and covering it with another somewhat larger in every way, but without a top); and a goodly supply of spring clothes pins, to be had of any hardware merchant for 20 cents a dozen. The above is a complete inventory of my own outfit. Having then provided yourself with these articles, with the addition of a squeegee muffled with a piece of soft flannel—an article which you can easily make by procuring a piece of small black rubber tubing of the proper length, and placing it in the center of a strip of flannel of equal length and about two inches wide. You then fold the flannel over on itself, thus inclosing the rubber tube, and fasten the whole between two narrow, thin strips of wood, drawing the rubber up close to the wood. You are ready for coating. For this purpose, you must secure the temporary use of some small room in which the paper can be coated, hung up, and left to dry. This room must meet three requirements; it must be dry, free from dust, and capable of being made absolutely light-tight during the drying of the paper. I am fortunate enough to have undisputed control of a small attic which serves admirably. Into this room, provided with a table large enough to hold your marble slab, on which the slab is carefully leveled, you carry all the articles mentioned above. The spirit or oil lamp is placed in its box, on which stands the large tray previously filled with water at 100 deg. Fahr., and containing the jar of emulsion and the small tray filled with warm distilled water. The ruby lamp stands on a table in front of you; the glasses, well cleaned and warmed to blood heat, and the paper with the side to be coated uppermost are placed on the table at your right; within convenient reach of your right hand stands the tray of warm water, and the leveled slab is within easy reach on your left. Turn the ruby lamp down as low as is consistent with the power of vision. Now immerse a sheet of the paper in the water in the small tray, leaving it there for a minute or two; then place it accurately on one of the glass plates, and sweep off all superfluous water with the squeegee, at the same time removing all wrinkles and air bells, and place in an upright position to dry slightly while you prepare a second plate in the same manner. Now balance the first plate on the tips of the fingers and thumb of the left hand, and pour on a sufficient quantity of the emulsion, about 1 drachm for every 10 square inches of paper. I use a silver soup ladle holding just enough to cover a whole plate. Gently tilt plate from you until the further end is completely covered; then as gently tilt it toward you until the emulsion completely covers the paper; then carefully place it on the leveled slab to set. Continue this operation until the slab is covered, when the paper first coated will probably have become sufficiently set to be stripped from the glass and hung up by clothes pins to dry, which in my room requires from six to ten hours.

The above is a somewhat lengthy description of the method by which, after much experimenting and some failures, I have succeeded in obtaining positive paper which gives me complete satisfaction, and I have experimental knowledge of most of the positive processes commonly practiced. I have gone somewhat tediously into details in order that the merest tyro, if he be but careful, cleanly, and patient, may be able to prepare his own emulsion paper. If the directions are carefully followed, success is sure to come with a little practice, and perhaps also, as in my own case, an added love for the beautiful and fascinating art of photography, which is a gentle and kindly mistress to those who woo her aright.

The exposure is somewhat long. With negatives of ordinary density and a kerosene lamp with a one and a half inch wick, from one to one and a half minutes is about right, the negative being held about 18 inches from the lamp. Considerable latitude of exposure is given by this process, which is a great advantage. My own developer is ferrous oxalate, in the proportion of one part of iron to five or six parts of oxalate, adding more iron occasionally to strengthen. Both the iron and oxalate solutions should be kept slightly acid, and I use no bromide, which I believe ruins the tone and diminishes detail. Of course, the acid clearing solution—one drachm acetic acid to 32 ounces of water—should be used.

Negative paper is prepared in the same way, substituting a more rapid emulsion for the slow one given above.

It may be worth noting that very good mat surface prints can be made by coating ordinary drawing paper of light or medium weight with this emulsion, but for contact printing from small negatives the results are rather coarse.

STUDIES IN PYROTECHNY.*

MANUFACTURE OF FIREWORKS IN THE SEVENTEENTH CENTURY.

IN the seventeenth century the manufacture of fireworks was all the rage in France. At that epoch, pyrotechnists, slaves of the world, were to be seen emulating each other in the production of utensils, toys, arms, and representations of different objects, such as edifices, figures of men, animals, etc. Casimir Siemienowicz devotes several chapters of his book, "Ars Magna Artilleriæ," to a study of these amusing apparatus.

These small manufactures, whose essential elements were the petard and rocket, were, according to Sie-

* Continued from SUPPLEMENT, No. 586, page 9351.

mienowicz, of three kinds—*masses, missils*, and *arms*. Under the generic name of *masses*, the author includes all pyrotechnical objects such as cylinders, barrels, bags, baskets, wheels, crowns, bouquets, fire batons, and fire chalices. Under the denomination of *missils*, he classes flaming arrows or javelins, fire pots, artificial vials, globes, and bullets. Among these, he distinguishes the *valet* of the pyrobolist, the *death's head*, the *rain of fire*, the *pyrotechnic hail*, etc. Finally, in this category he arranges arms, targets, shields, etc., and sabers, cimeters, swords, cutlasses, and fire lances.

As an example of these various pyrotechnic toys, we shall give a description of the fire chalice. "Have made," says our author, "a wooden cup or chalice . . . like those that we use on the table, and of such a form as you like. Its bottom, from the base to the concavity of the vessel, must be provided with an aperture into which will be inserted a wooden or metallic tube charged with a composition of powder, sulphur, carbon, antimony, and sea salt, which will produce a very dark and black flame.

FIG. 1.—A FIREWORK OF THE SEVENTEENTH CENTURY.

"You will fill the concavity of the cup with serpents. . . . You will cover these very properly with a wooden disk three or four lines thick, and with such accuracy that its lower surface shall rest immediately upon the heads of the serpents, and that its circumference shall join the interior of the vessel. Finally, smear the rest of the concavity of the chalice up to the brim with tar.

"The pyrobolist engineer will be able to find a thousand other sorts of inventions that he will make succeed through this chalice; particularly for drinking to the health of some person of mark.

"He will first set fire, from beneath, to the composition hidden in the bottom, and during this time he will promptly drink the liquor that has been presented to him in the said vessel. Then, lifting the latter above his head, he will wait until the fire has reached the serpents and the latter have risen into the air to produce their effects.

"But I warn you here that it is necessary to pour so little wine, or whatever it be, into the cup that it may be drank in one or two draughts, or else it will be necessary that he who drinks shall have a throat made after the German style. I mean that the goblet should be emptied at one draught, for one runs the risk here not only of burning his nose, but also at times of being sent to kingdom come."

It is useless to observe that it would be very easy now to ward off this danger of "being sent to kingdom come" by having recourse to the use of a small electric lighter.

Siemienowicz enters into long details touching the manner of manufacturing pyrotechnic edifices: "The frames of castles, palaces, triumphal arches, towers, etc., will be lined within with various kinds of fireworks, and be covered with a quantity of paper petards."

The following is the chapter relating to the figures of men or animals, which are obtained by moulding: "After covering his model with soap or wax, the pyrotechnist will cover it with a crust one or two lines in thickness, made of paper pulp mixed with glue water. A short time afterward, the model will be dried with a little fire."

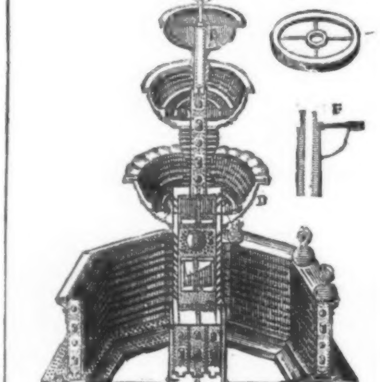


FIG. 2.—DETAILS OF FIG. 1.

The author then teaches us how to insert the fireworks whose combustion is to please spectators. "In the hollow space," says he, "you will very adroitly adjust one or more tubes, which have been formed according to the incurvation of the parts of the body, and which must be well bound and tied for fear that the violence of the powder may destroy them before they have produced their effects. And one must remember to attach all to some solid and firm base, so that they may neither shake nor waver in any wise. Finally, one will cover them with a cardboard envelope, and then one will make the commissures strong and firm with glue." This is the process when it is a question of the nude; with costumed figures the thing is simpler. "One begins by massing the tubes nearly according to the form to be given to the body. Then the statue is covered with some garment of linen, silk, or paper, cut out, sewed, and colored according to the architect's design. Upon the tube forming the head of the machine is adjusted a cardboard mask. Paper shoes are put on the feet and gloves on the hands. Into the head there is usually put a globe charged with a slow burning composition. . . . All the animals that it is proposed to represent are clothed in their own skin."

As regards the arrangement of the fireworks within the envelope, Siemienowicz distinguishes two systems. "There are," says he, "some pyrotechnists who are content to cover a single tube with the cardboard envelope, and to pass this through the body of the statue from one end to the other, as may be observed in the design of Fortune" (Figs. 1 and 2). Such is the first manner. The following is the second: "Some pyrotechnists dexterously fill the arms, thighs, hands, and feet of their statues with serpents or petards, or else with tubes very artistically arranged, which communicate fire in succession through small channels, which carry it from one to the other until the last is consumed. This order can be seen in the representation of Bacchus holding a fire chalice in the hand" (Figs. 3 and 4).

Figs. 1, 2, 3, and 4 explain themselves so well that it is useless to go into details concerning them.

The greatest piece of pyrotechnic work of this epoch is the one that was produced at Paris in 1628 in honor of Louis XIII., at the time of his return from the siege of La Rochelle. It is thus described by Grodicki, grand master of artillery of the kingdom of Poland: "Henry Clarner, of Nuremberg, fixed in the middle of the Seine what appeared to be a great rock that seemed to be inaccessible on account of its dangers, and frightful by reason of its precipices, and to this a young lady was chained.

"A short time afterward, there emerged from the water a frightful marine monster with head of fearful form that emitted fire and flames from the jaws, and that vomited flames and sparks of fire in so great abundance that it caused as much fear as admiration. This horrible beast was carried by the stream toward the rock, and seemed desirous of swallowing the miserable victim that had been destined for it."

Fig. 5 explains the structure of the monster sufficiently, without the necessity of further details. Let us go on with the description:

"As it (the beast) was about touching the rock, a young Hero was seen to appear in the air, armed to advantage and mounted upon a great winged horse running at all speed, and who, presenting his spear at the horrible monster, pierced it through and through. After this there appeared a very great quantity of fire-

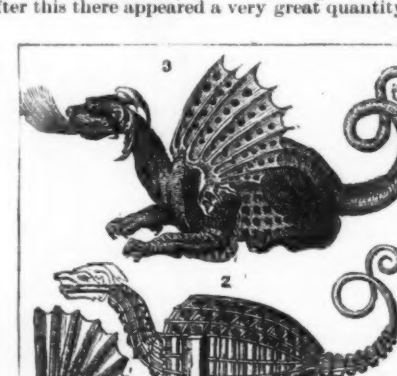


FIG. 5.—FIREWORK REPRESENTING A DRAGON; WITH DETAILS.

works from the bodies of the monster, cavalier, and lady. This lasted for some hours without cease, during which these bodies continuously sent differently prepared fireworks into the air.

"What furnished the subject of so pretty an invention was the fable of Andromeda."

It is not difficult to grasp the allegorical meaning of this complicated fabric. The representation was given for the purpose of putting before the eyes of the people the true adventures and high deeds of arms of our very Christian king performed during the siege of La Rochelle, and which it represented to us under the form of Perseus.

"The winged Pegasus that this feigned liberator rode was to be understood as the martial virtue of this great monarch, always provided with the wings of the vivacity of his mind and with a laudable promptness in all his enterprises.

"Andromeda was the true image of the Catholic religion, then being oppressed by the reformed Protestants of La Rochelle.

"The rock was the city of La Rochelle, which was well enough understood from the word 'roche' or 'rocher.'

"Finally, the marine monster slain by Perseus, and the delivered Andromeda, signified the Catholic religion, destined to death by the Huguenots, its enemies, and set at liberty by the taking of the city; the Protestants reduced under the yoke, their own religion punished, strangled, and entirely suppressed by the help of our generous Perseus."

It was thus that, in the seventeenth century, pyrotechny co-operated in the celebration of public fetes.—*La Nature.*

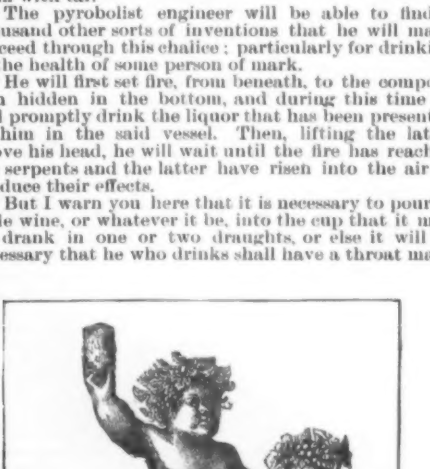


FIG. 3.—A FIREWORK REPRESENTING BACCHUS.

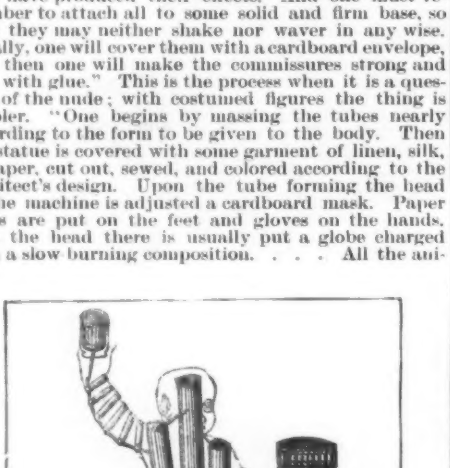


FIG. 4.—DETAILS OF FIG. 3

BARRELS are now made from water pulp, and the inventor of the process says that weeds and rank grasses will produce an excellent pulp for this purpose, and that thus waste lands may be made productive and profitable. The cost of manufacturing the paper barrels is no greater than that of making the wooden article, and, with the patented machine, it is said that two men can produce 600 barrels in a day.

[Continued from SUPPLEMENT, No. 593, page 9476.]

CLIMATE IN ITS RELATION TO HEALTH.*

By G. V. POORE, M.D.

LECTURE II.

THE FLOATING MATTER IN THE AIR.

IT is a well known and universally acknowledged fact that different climates are inhabited by different animals and plants. It is also well known that animals and plants which are indigenous to tropical and warm climates quickly die in colder regions, unless artificially protected. In polar regions vegetation becomes exceedingly scanty, although the polar seas teem with life. Animal life is more easily supported in cold countries than is vegetable life. Man, as we have seen, is able to encounter for months the very extremities of cold without any detriment to his general health, but he is enabled to do so only by artificial help from clothing and firing, by building a warm hut for shelter, and by packing close into this hut for the sake of mutual warmth. The conditions under which the crew of the Eira enjoyed such rude health in Franz Josef Land, conditions of which overcrowding and dirt were the chief characteristics, would be stigmatized in this or any temperate climate as most unhealthy, and such as would certainly quickly prove highly prejudicial, and in all probability cause sore throats, lung disease, consumption, and other troubles.

Such conditions of life in the tropics would be scarcely less fatal, probably, than was the Black Hole of Calcutta. Why is it that conditions of life which would be fatal in the tropics are apparently harmless at the pole?

The only explanation which I am able to offer is this, that at the pole, putrefaction, decomposition, and decay of effete matters is, owing to the low temperature, impossible. What we call dead organic matter becomes a prey to lower forms of life, both animal and vegetable; but in the polar regions these lower forms of life, if existent, are unable to manifest any vitality, and those processes of which putrefaction is the type are in abeyance.

The extreme cold and the extreme dryness of polar regions are both opposed to anything like putrefactive change; and it is a remarkable fact that among the Eskimo (who absolutely never wash, who inhabit their clothes almost as continuously as they do their skins, and who live in a state of filth without its parallel in the world) filth disease should be conspicuous by its absence. If cold and dryness check putrefaction, warmth and moisture equally encourage it, and in tropical climates (unless the dryness of the air is very great) putrefaction runs riot, and diseases dependent upon the decay of organic matter run riot also. Up to this point we seem to have arrived at certain conditions:

1. That the varying chemical constitution of the atmosphere has no great effect upon health.

2. That the amount of moisture in the air may vary considerably, and by so doing may cause a certain amount of comfort or discomfort to invalids, but that the humidity of the air has no great effect upon health except in so far as it affects the processes connected with putrefaction and decay.

3. That the extremes of heat and cold *per se* can be borne by healthy men under favorable circumstances without any very serious results; but that a high temperature is indirectly dangerous, because of the facilities which it offers, so to say, to all putrefactive changes.

As far as we have gone, we seem to be landed in the conclusion that none of the atmospheric conditions we have considered is of necessity directly harmful to the individual; but that, indirectly, those conditions which favor putrefactive and allied changes may be very prejudicial to his health.

A glance at two of the diagrams suspended from the screen will serve to show you that there is a most unmistakable connection between the temperature of the air and the death rate from two classes of disease.

The first shows that the deaths from diseases of the respiratory organs rise as the temperature falls; or, in other words, that in cold weather, death from lung disease reaches its maximum. We must not conclude from this that cold, *per se*, is the great cause of lung disease, for I shall probably convince you, before these lectures are finished, that overcrowding, intemperance, starvation, and a sewage-sodden soil are more active causes of this form of disease than cold.

To persons whose lungs are already diseased, cold is very trying, and the extremes of cold kill off, as it were, the sufferers from lung disease more than they cause the disease itself. Again, old people are liable to suffer from inflammation and congestion of the lungs; and in fact, this is one of the recognized ways in which death comes to the aged, so that many of the deaths registered in very cold weather as deaths from lung disease are in reality those of very old people and others whose debt of nature was due or overdue.

The other diagram shows that during periods of high temperature the mortality is high from diarrhœa. The cause of this diarrhœa is probably to be found in the facilities afforded by high temperature for putrefactive change. In warm weather, as we know, milk "turns," meat goes putrid, fruit gets rotten, and all collections of putrescible matter are more than usually offensive to the nose. The sewer gratings smell, and the kitchen sink is malodorous in warm weather; and it is in warm weather especially that we write to the *Times* to complain of the filthy condition of our Father Thames. The consumption of putrid food, and the inhalation of putrid air, are both acknowledged causes of diarrhœa; and it is propably *via* putridity, so to say, that summer raises the death rate from diarrhœal diseases.

As we advance into the tropics, speaking generally, the amount of disease increases; and if we look at Keith Johnston's map of the "Geographical Distribution of Disease," we find that the chief diseases are:

1. Malarious diseases (fever, ague, and dysentery).
2. Yellow fever.
3. Cholera.
4. Typhoid and allied forms of fever.
5. Ophthalmia.

Now each of these diseases I have named is certainly connected with putrefactive and allied conditions. Malaria is caused by decay of organic matter in marshes and similar places. Yellow fever is a disease mainly of the cities of the western tropics, and is certainly mainly dependent on the putrefaction of fæcal and other animal matters. Of cholera it may safely be said that fæcal discharges are one medium for its propagation, and that it gets its strongest hold where putrefying filth is allowed to pollute the soil and air. Typhoid is a recognized filth disease; and ophthalmia, which is the scourge of Egypt, and other Mediterranean stations, has been clearly shown, in more than one instance, to depend on air fouled by fæcal decompositions.

Here, then, we find that an enormous proportion of tropical disease, if not wholly dependent on, is in some way inseparably connected with, the putrefaction and decay of organic matter, whether vegetable or animal.

Undoubtedly, one of the greatest scientific advances which has been made in the present day was made by Pasteur when he demonstrated that fermentation and putrefaction were due to the growth of low forms of vegetable life at the expense of the fermentable or putrescible liquid; and that if the aforesaid vegetable organisms can be excluded from the fermentable or putrescible matter, then neither fermentation nor putrefaction will take place, and the fluid will remain unaltered, even for years.

Unless special precautions be taken, any putrescible fluid, if left to itself, will putrefy. How is this brought about? The answer is that the active agent of the putrescible change is supplied by the surrounding media. The soil, the water, a neighboring putrefactive focus of some kind, supplies the necessary organism; this is wafted through the air, and sets putrefaction a-going in the putrescible fluid.

Apart from all other considerations, this undesirable sequence of air-borne germs, putrefaction disease, is enough to invest with the deepest interest the question of the floating matter in the air, to which we shall now, for a short time, turn our attention.

A London audience, I feel, is not unlikely to have some sort of prejudice in favor of the proposition that floating matter does exist in the air, and that in no small amount.

As to the nature of the matter which may be found floating in the air, the variety is infinite, and the distance which floating matter may be carried by the air is also very variable. Thus I have the authority of Mr. Buchan, the author of the article "Meteorology" in the "Encyclopædia Britannica," for stating that "the tornado which passed over Mount Carmel (Illinois), June 4, 1877, swept off the spire, vane, and gilded ball of the Methodist church, and carried it bodily fifteen miles to the northeastward."

Again, whirlwinds occasionally raise the fine sand of African deserts high into the atmosphere, whence it is wafted distances which seem incredible, and has been known to fall upon the sails of ships 600 or 800 miles away; and in the city of Berlin have been found organisms which, according to the learned, must have had their orign in African deserts.

The fact that comparatively large and appreciably ponderable particles can be carried such long distances through the air, will prepare the mind to accept without difficulty the proposition that particles so attenuated as almost to elude the grasp of the mind's eye may be transported any distance.

This important question of the solid matter in the air has, for some years past, been attracting an increasing amount of attention. The dust which is deposited in sheltered places comes from the air, and many microscopical examinations and chemical analyses of dust have been made. The dust of Dublin was found by Tichborne to contain from 29 to 45 per cent. of organic matter, which was chiefly composed of finely ground horse droppings; and among the unpleasant things which have been found in dust may be mentioned: Scales from the human body, the dried matter from suppurating wounds, the insects which produce the disease called itch, the fungus which causes ringworm, and scales from small-pox pustules.

Reading such a list as this, we cannot help feeling that the potentiality for evil of dust and dirt may be very great, and the natural reflection will force itself upon us, "Do these things, and such as these, become dried, and then, lifted by the wind and carried through the air, work mischief at a distance from their source of origin?" The floating matters in the air are mineral, vegetable, and animal. If air be directed through a suitable apparatus, the details of which I need not trouble you with, the solid particles will be deposited, and may be examined with the microscope. In dust collected in this way microscopists have recognized a variety of things, and Ehrenberg has recorded over 200 of the lowest forms of life thus floating in the air. Blackley was one of the first to direct attention to the enormous amount of pollen (the fertilizing dust of flowers) to be found in the air, even at considerable elevations, and Maddox has specially directed attention to the innumerable spores (the reproductive seeds) of different forms of fungi.

The evidence of the richness of the air in spores of fungi is before us every day, for if we leave any moist organic matter exposed to the air, we find it "mouldy" after a lapse of a few hours. These "moulds" are in great variety, and differ considerably in color and "habit," as a gardener would say. Whence came they? The most probable answer is that the spore, or seed, was deposited from the air upon the organic matter, which served as a suitable soil, where the spore quickly reproduced its kind to ripen and give off, in its turn, its thousands or millions of spores to every passing breeze.

The systematic examination of the air is now being carried out in many laboratories, but nowhere more systematically and thoroughly than at the observatory of Mont Souris, in Paris. The work of this observatory is, to some extent, of a novel character, so that I think I shall not do wrong in giving you a sketch of it.

The observatory is under the care of the municipality of Paris, and is situate in the park of Mont Souris, in the extreme south of the city, just within the fortifications. The observatory is under the direction of M. Marie Davey, and its work is divided into three sections, viz.:

1. Meteorology proper, including magnetic and electrical observations.
2. The chemical analysis of air and rain.
3. The microscopical study of the organic matter suspended in the air, or in the rain and other water collected at the observatory. This department is under the control of M. P. Miquel.

At the close of every year the observatory issues the "Annuaire de Mont Souris," a book full of information, and from which, as well as from Miquel's "Organismes Vivants de l'Atmosphere," much that I am going to say has been derived.

Dr. Miquel has, with regard to the air, made two series of observations, one having reference to the forms of moulds, fungi, and other lowly organisms, as well as inorganic matter, and the other with reference solely to bacteria and micro-organisms closely allied to them.

Pasteur seems to have been the first to call the attention of the scientific world to the importance of studying the organic matters wafted by the air, and, in 1862, he published a memoir on the subject in the "Annales de Chimie et de Physique." For the next eight years, work in this direction was not very active; but in 1870, Dr. R. L. Maddox published in the *Monthly Microscopical Journal* the results of a series of experiments made by him with the object of determining the relationship between the organic germs of the atmoshere and the other meteorological conditions. The main facts established by Dr. Maddox were as follows:

1. The immense variations which occur in the number of spores floating in the air, variations the extremes of which are represented by the numbers 1 and 250.

2. The small influence which, in the open country, the direction of the wind has upon the number of spores.

3. Their increase in summer, especially (in England) July and August.

4. The velocity of the wind has no constant relation to the number of spores.

5. In very windy weather the inorganic sediments are increased, but there is no increase of spores.

6. Wet weather seems to have the effect of fixing the mineral matters in the soil, but has no similar effect on the spores.

Dr. Maddox found that the spores collected from the air belonged to every form of fungus, and to many forms of lichen. Further, he found portions of green algæ and a great variety of pollen. Further, Dr. Maddox succeeded in cultivating in suitable liquids many of the spores which he collected.

It was not till 1876 that the systematic observation of air-borne spores was commenced at Mont Souris by Dr. Miquel.

Taking the average of the four years 1879-82, Dr. Miquel found that each liter of air contained from 12 to 15 spores, and that, in general, they were slightly more abundant during hot years. The effects of season were well marked. Thus in winter there were 6·6 spores per liter of air; in spring, 16·7; in summer, 22·8; in autumn, 10·8.

By means of a most ingenious registering aeroscope, Dr. Miquel has been enabled to observe the hourly fluctuations in the number of spores. This fluctuation is very great indeed, and the causes of it are not always apparent. One fact seems to come out clearly, viz., that a fall of rain has the effect of partially clearing the air of spores for a time.

The causes of the hourly fluctuation are, according to Miquel, mainly two, viz., remote and local. Let us imagine a mass of air traveling from north to south. Coming from regions of ice, and originally very pure, it strikes a continent, and the mass of air which impinges on the soil makes almost a clean sweep of floating spores, and largely enriches itself at the expense, as it were, of the masses of air following in its wake. Thus the richness in spores diminishes as long as the air blows strictly from one direction.

Among local causes of variation may be mentioned the neighborhood of great towns or other centers of spore production.

By means of the registering aeroscope, Miquel has been able to estimate the amount of mineral matters in the air. When the wind blows from the north (*i. e.*, over the city of Paris), at Mont Souris there is a great abundance of inorganic matter and particles of carbon, due to the combustion of fires and the cleaning of the streets, etc. During rain there is an immediate and almost complete disappearance of these matters. Miquel ("Organismes Vivants de l'Atmosphere") warns us that the nature of the particles of dust floating in the air is so varied that one of the first necessities of the experimenter is some sort of classification.

The mineral matter is very varied, carbonaceous, ferruginous, silicious, or cretaceous. These mineral particles may be submitted to chemical tests for the determining of their nature. Sometimes their rough angles and general appearance at once show that they are not organized, but this is not always the case, and, since the divisibility of these mineral particles is infinite, it is not possible, very often, to distinguish them by their appearance alone from micro-organisms of the family of bacteria.

The coarse particles present in the air are not without their use, as they give, as Pouchet said, a character to the whole of the floating matter collected, and enable the observer to say very often whence the air has come. The air of rooms, for example, contains a quantity of colored textile particles which are seldom met with in the air of the country. In the streets we find in the air the detritus of clothing, but the textile particles are more rare, and are diluted, as it were, with matters of vegetable and animal origin. In the country, the chief part of the organized matter is formed of vegetable fibers.

The dust of the air is usually collected by exposing a glass slide, previously smeared with some sticky fluid, to the air current. In making choice of fluid care must be taken that it is not of a character to encourage the growth and multiplication of organic particles, such as the spores of fungi. Miquel asserts that glyceria alone is not suitable, because it attracts water, and then forms a most active cultivating medium. He advises a mixture of glycerin and glucose, which he says is stable, colorless, transparent, and very sticky.

Another difficulty in the examination of the dust of the air is the measuring of the volume of air which passes over the dust trays. Unless this be done, it is evident we get no exact knowledge as to the relative purity or impurity of the air examined. I do not propose to enter into details of the machines for aspirating known quantities of air, but it must suffice to say that at Mont Souris the difficulties of measurement seem to have been completely overcome.

As to matters which are visible with the aid of the

* Three lectures before the Society of Arts, London. From the Journal of the Society.

microscope, Miquel says: "Apart from the ova of infusoria, whose existence in air dust is very uncommon, as well as the bacteria, which are indistinguishable among the other matters, we have to deal with: 1. Starch grains. 2. Pollen grains, capable of fertilizing other plants of their own species, but incapable of germination. 3. Spores of cryptogams, capable of germinating, and of giving rise to determinate forms of fungi. 4. Complete plants, generally unicellular.

Pollen is very common in the spring and summer, and tends to disappear in the autumn and winter. It never completely disappears, even in the winter. In Paris, the amount of pollen found in the air is sometimes very great, and may amount to as much as 5,000 or 10,000 grains per cubic meter.

Spores of cryptogams are the most common of all organic particles found in the air.

CHIEF CHARACTERS OF AIR DUST.

	Spores.		Pollen.	Mineral.
	Young.	Old.		
In summer—wet.	Many	Few	Much	Little
In summer—dry.	Few	Many	Much	Much
In winter—wet...	Few	Few	None	Little
In winter—dry...	None	Many	Little	Much
In dwellings, etc.	Few	Many	Very few	Very much
In sewers........	Many	Few	None	Little

So far we have been considering particles which are comparatively gross—microscopic certainly, but, nevertheless, plainly visible under the microscope, and distinguishable the one from the other by the eye of the expert.

The lower forms of fungi, the so-called schizophytes, which increase almost entirely by the simple process of splitting and dividing, are very much more difficult of detection. Though small, these fungi are by no means to be neglected, for to them belong the bacteria and allied kinds of which we have heard so much of late. These fungi are known to be the cause of some forms of putrefaction, to be the cause of sour milk, rancid butter, ropy beer, etc. They have been found in connection with many most virulent diseases, and are known to be the active cause of some of them. Hence it follows that the study of the bacteria in the air is deemed at present to be of the highest importance. When in small numbers, and when mixed with other matters, they elude the eyes of the most careful investigator, so that recourse must be had to other methods of investigation.

Such a method of investigation is found in what are daily becoming more and more familiar to us as cultivation experiments.

Of the precautions necessary in conducting such experiments, and of the enormous care and trouble which they involve, I will say nothing, but I will merely state that, in principle, the experiment consists in bringing a measured quantity of air in contact with a putrescible fluid which has been previously sterilized. At Mont Souris, the fluid used is a *bouillon* of beef. It is sterilized by repeated heating, and if, after a month or so, the tube containing the *bouillon* is found to be clear and transparent, and without change, then it is fit for testing the air.

The sterilized tubes are unsealed, a measured quantity of the air to be tested is drawn through them, and they are then resealed and kept for several days in a uniform warm temperature. If at the end of this time no change has taken place, then we have no evidence that the portions of air admitted to the tube contained any bacteria; but if the contents of the tube become cloudy and present evidence of bacterial growth, then the portion of air admitted to the tube contained at least one active germ capable of growth. M. Miquel has been in the habit of distributing the air to be examined in a large number of sterilized tubes. For example, he would take 100 liters of air from his room, and inoculate with it 50 tubes containing sterilized *bouillon*. If, after this, ten of the tubes showed bacterial growth, he would know that his 100 liters of air contained at least ten active bacteria, and he would state the bacterial richness of the air as equal to 100 bacteria per cubic meter.

It must be remembered that this and similar maneuvers have been practiced day after day, and sometimes several times a day, at Mont Souris, and I will ask you to think for a moment of the immense labor involved, and of the enormous quantity of material necessary—the thousands of tubes, the gallons of sterilized *bouillon*, and the amount of subsidiary apparatus.

The expense involved in such extensive investigation is not small either, and we cannot but admire the spirited action of the Paris municipality in establishing this most important observatory.

There are many ways of carrying out the experiments for testing the purity of the air, and, in the hands of different workers, the details have been much varied.

I propose to show you, with the assistance of my friend, Mr. Joseph Lister, a rough method of treating the purity of the air by means of a potato. I have upon the table two bell jars and an old potato, to which I will invite your attention. We have been at some pains to deprive this potato of all living germs. To this end it has been cleaned, and its outer skin has been washed with a coating of corrosive sublimate, which is about the most powerful antiseptic known. Further, our potato has been subjected to a prolonged steaming, which has thoroughly cooked it. We may assume that the potato has been in this way freed from living germs, or, in other words, that it is sterilized.

We next take one of the bell jars, and wash its interior with corrosive sublimate solution, so as to kill any germs which may be adhering to it, and, further, we heat the interior with the flame of a spirit lamp, so as to destroy any living thing that may be in the contained air. Next, we remove the potato from the vessel where it has been steaming, and cut it in halves with a knife, the blade of which has been previously heated in the flame of a spirit lamp. One half we place under the sterilized bell jar, the other half we will leave exposed to the air of the room for a few minutes, and then place it under the other bell jar. In order to keep the air in the bell jars moist, we place some blotting paper moistened with a solution of corrosive sublimate in each. We will now put these potatoes away in a cupboard, and examine them again at the next lecture. We ought to find that the half potato which has been kept under the sterilized bell jar will remain free from growths, while if, as I suppose, the air of this room be charged with living organisms, then we shall find upon the half potato which has been exposed to it centers, more or less numerous, of fungoid and bacterial growth.*

This is but a rough method, no doubt, but it is often of great service. It does not, like the more elaborate method of Miquel, give you anything like an exact quantitative estimate of the richness of the air in living microbes, but it gives a rough idea, and it will serve to give a rough idea to you of the nature of the experiments which are necessary for testing air for bacteria and allied organisms.

I will now bring before you some of the results of Miquel's experiments. Bacteria in the air, like the spores of fungi, are liable to great variations. In the year 1880, there were, on an average, 560 bacteria in each cubic meter of air examined at Mont Souris. In 1881, the average was 590, while in 1882 the figure reached was only 320. In the "Annuaire de Mont Souris" for 1884, M. Miquel gives the weekly average of bacteria found at Mont Souris from January, 1880, to October, 1883. These are given, arranged in parallel columns, with the meteorological data for the same period (barometric pressure, heat, moisture, wind, electricity, ozone, rainfall). From a careful examination of these figures, Miquel has arrived at the opinion that bacteria are apt to increase during periods of high barometric pressure, a rule, however, which is by no means absolute.

Changes of temperature do not produce very sudden changes in the number of bacteria. Sudden increases are without doubt most common in summer, but prolonged heat often causes a diminution in the number of microbes. Miquel believes that the thermometer may give the key to certain seasonal variations, but that changes of temperature will not explain the weekly variations.

Bacteria reach their maxima when the hygrometric conditions are feeble, *i. e.*, when the air is dry. This is explained by the fact that moist conditions of atmosphere correspond with times of heavy rain, and when the surface of the ground is sodden, which are always periods of few bacteria.

The direction of the wind has a very decided influence on the number of microbes collected at Mont Souris, which, be it remembered, is situated in the extreme south of Paris. Of thirty maxima (over 600 microbes per cubic meter of air) observed at Mont Souris—

14	occurred	with the	wind	N.E.
4	"	"	"	N.
4	"	"	"	N.W.
2	"	"	"	W.
5	"	"	"	S.W.
1	"	"	"	E.

With regard to the relationship between ozone and bacteria, Miquel admits that when ozone is in small quantities, bacteria often increase. He gives, however, no credence to the belief which has been put forward by some, that ozone destroys bacteria. The relationship observed between ozone and the number of bacteria is illusory, and is caused by a meteorological condition which is capable at once of producing ozone and lowering the number of microbes. Rain and moisture have, apparently, this double power.

For the year 1882-83, Miquel made calculations for every three days, and comparing the number of bacteria with the rainfall, he came to the conlusion, or rather was confirmed in a conclusion which he had arrived at three years previously:

"The number of aerial bacteria, which is always slight during times of rain, increases as the drying of the soil progresses, and decreases if the dryness is prolonged beyond a week."

The seasonal changes of bacteria observed at Mont Souris in 1882-83 were as under:

Autumn....	115	microbes per cubic meter.
Winter............	115	" "
Spring...	550	" "
Summer..........	?	" "

The enumeration of bacteria was carried on, not only at Mont Souris, but also in the Rue de Rivoli, which is near the center of the great city of Paris. This work was intrusted to M. Riquet, under the guidance of M. Miquel, and from these researches carried on since January, 1881, the following seasonal averages have been deduced:

1882-83 (Rue de Rivoli).

Autumn.........	2,060	microbes per cubic meter.
Winter	2,040	" "
Spring...........	1,900	" "
Summer.........	3,960	" "
Yearly mean....	2,490	" "

Microbes at High Altitudes.—In conjunction with M. Freudenreich, of Berne, M. Miquel investigated the question of the richness in microbes presented by the air of high altitudes. Many investigators have touched this question, but the difficulties of experimenting are very great, and most of the earlier experiments are seriously tainted with error.

The method pursued by Messrs. Miquel and Freudenreich was as follows: A glass tube was drawn to a point at one end. A plug of spun glass (*coton de verre*) for filtering the air was trust toward the point, and retained in position by a slight contraction in the tube behind it. A second plug of spun glass was thrust down to the contraction, and then, the point being sealed, the tube was submitted to a temperature of between 200° and 300° C. for some hours. After cooling, the open end is closed with a cork.

The method of conducting the experiment is as follows: The tube is mounted on a stick, and, the cork being removed, it is placed with its capillary point slightly raised, and facing the wind. An aspirator is then fixed to the open end, and the fine point is removed by means of the blowpipe and a pair of heated forceps. By means of the aspirator, a measured quantity of air is then drawn over the sterilized plug of spun glass. The pointed end is then resealed, and the cork replaced. The plugs are then removed, and stirred up with 30 or 40 c. c. of sterilized water, and this water is distributed in any number (ten, twenty, thirty) of flasks of sterilized *bouillon*, which are then kept at a temperature of 30° C. to 35° C. Knowing, on the one hand, the number of successful cultivations in the *bouillon*, and, on the other, the volume of air which had been drawn over the sterilized cotton wool, it is easy to estimate the number of microbes in any known quantity of air.

The following are the details of a few of the experiments carried out by these two enthusiastic observers:

On July 12, 1883, M. De Freudenreich left Thun, and climbing the Bernese Alps, reached the neighborhood of the Strahlegg Pass, at an altitude of 3,200 meters, and filtered through a plug of spun glass (at a height of one meter above the ice) 300 liters of air. A week later he distributed this plug among twelve portions of sterilized *bouillon*. Two and a half months later, no growth had taken place in the *bouillon*, which remained absolutely limpid.

Three weeks later, two portions of air, of 500 and 400 liters respectively, and taken from altitudes of 2,100 meters and 3,976 meters, were filtered through sterilized plugs, and the plugs were afterward distributed through portions of *bouillon*, but no growth took place, the *bouillon* remaining perfectly limpid.

In a third experiment, M. De Freudenreich filtered 1,500 liters of air through six plugs on the top of the Schilthorn, at a height of 2,972 meters. The subsequent cultivation experiments gave, as in the other cases, negative results.

"Thus," says M. Miquel, "2,700 liters of air taken from elevations varying from 2,000 to 4,000 meters above sea level did not furnish either a bacterium or spore of fungus capable of cultivation and growth in neutralized *bouillon*, a liquid possessing the highest powers of developing schizophytes and fungi; for at the observatory of Mont Souris it is common to see 400 or 600 fungoid spores per cubic meter of air developed in the *bouillon*."

With air taken on the level of the town of Thun, M. De Freudenreich's results were very different. The results may be expressed as follows:

BACTERIA IN TEN CUBIC METERS OF AIR.

1. At a height of from 2,000 to 4,000 meters	0·0
2. On the Lake of Thun (560 meters)...	8·0
3. Near the Hotel Bellevue, Thun.....	25·0
4. In a room of the hotel................	600·0
5. In the park at Mont Souris.........	7600·0
6. In the Rue de Rivoli (Paris).........	55000·0

These analyses were all made about the same time.

"In giving these results," says M. Miquel, "I do not pretend to establish, even approximately, the comparative richness in microbes of the air of Switzerland and Paris. In order to firmly establish such a fact, a prolonged series of experiments would be necessary. But the above results enable us to conclude forthwith that the air of the Valley of Thun is very poor in germs. The objections might be made that I had allowed my air dust to remain eight or ten days on the filter plugs prior to the attempts at cultivation. This might have the effect of lowering the number of bacteria, because some of the germs might die in the interval of falling on the cotton and subsequent immersion in the *bouillon*. But this supposition cannot constitute a serious objection, for experiments show that the tenderest bacteria will resist five or six months drying, and that micrococci preserve the faculty of reproduction for years."

The diminution of microbes in the air of the Swiss mountains seems to Miquel to be due—

1. To the diminution of atmospheric pressure. At a height of 4,000 meters, a volume of air from the plain would occupy twice its original space, and thus the atmospheric dust is diluted.

2. To the lessened density of the air, which becomes less and less able to hold solid bodies in suspension.

3. To the progressive disappearance of the productive foci of bacteria. At the snow line the disappearance of these foci is absolute.

To give an idea of how the atmospheric purity increases as we rise perpendicularly above the sources of microbes and infecting particles, Miquel mentions the result of two analyses of air obtained simultaneously; the one in the Rue de Rivoli, and the other from the top of the Pantheon, the difference in elevation being 100 meters. At the lantern of the Pantheon the air is twenty times more pure than at the Mairie of the 4th arrondissement, situate in the Rue de Rivoli.

Many other reasons for the rarity of germs at high altitudes might be invoked. Among these the cold is not without influence, although the power of cold to kill microbes has always seemed to M. Miquel to be feeble. In December, 1879, Miquel submitted some sealed tubes containing bacteria in distilled water to a temperature of —7° C. for twenty days, and subsequently to a temperature of —30° C., but without destroying the vitality of the bacteria. In 1881, a director of the Swiss Ice Company sent to M. Miquel a block of ice eleven months old, weighing 50 kilogrammes, and which had been taken from the Valley of Joux. In three samples taken from the center of this block M. Miquel found examples of a micrococcus of the nature of sarcina, and he calculated that this block contained 780,000 bacteria which were still alive.

In December, 1882, by the kindness of Prof. Raoul Pictet, of Geneva, M. Miquel was enabled to submit some of his tubes containing bacteria to a temperature of —100° C., and in this experiment it was found that many bacteria which are unable to resist a temperature of 70° C. for two hours were able to withstand this degree of cold. One fact was noticeable, viz., that some of the bacteria had "grown old," as Miquel puts it, and when they were sown in nutritive liquids, growth was delayed for three days, instead of being observable at the end of twenty-four hours, as is usually the case.

M. Miquel's researches on the air of the wards of hospitals were carried out at the Hotel Dieu and the Hospital Notre Dame de la Pitie, and with the result that for the whole year the hospital air contained on an average 11,100 bacteria per cubic meter, as against 850 bacteria per cubic meter of the air of the Rue de Rivoli.

Taking the whole year through, it was found that the increase and decrease of bacteria in the air of hospital wards obeyed laws very different from those observed in the open air. The hospital bacteria, in fact, reached their minimum at the time when the

* These potatoes were examined at the concluding lecture, with the result that the protected potato showed three centers of growth, as against eleven on the potato which had been exposed to the air of the room.

windows could be kept open, *i. e.*, in June, July, and August, when the numbers fell to about half of the average, viz., 5,500, at a time when the bacteria in the street had attained a maximum of about 1,300, or 50 per cent. in excess of the average. The maximum of the hospital (28,000) was reached in January, when the weather was cold and the windows shut, and the average in the street had fallen to 160.

Reflecting on this curious and interesting result of his inquiry, M. Miquel says: "If hospitals be built in the middle of cities, the surrounding quarters must receive microbes which possibly are not always harmless," and he quotes M. Bertillon in support of his proposition. M. Bertillon says:

"I wish to point out the lessening week by week, and the final cessation on the 17th week of this year, 1880, of deaths from small-pox in the quarters of the Sorbonne, which was so exceptionally smitten by the malady in January, February, and March, for the diminution no less than the aggravation will serve to show the cause of the ravages. By referring each case of small-pox to the house in which it had originated, we found them grouped round the annex of the Hotel Dieu, as round an epidemic center squeezed in between the Seine and the Boulevard St. Germain. In this district, with 10,000 inhabitants, there were forty-nine deaths from small-pox in January and February, notwithstanding that its due proportion, having regard to the population and the intensity of the epidemic, would have been three. How are these forty-six deaths in excess of the average for the rest of the city to be accounted for, except by the fact that the annex of the Hotel Dieu, around which the stricken houses were situated, had at the time been made a depot for small-pox cases, whither they were all sent for the laudable purpose of isolation? This measure seems to have changed the mode of transmission rather than to have suppressed it, and the small-pox, instead of going from bed to bed, spread from house to house round the variolous center, and now that the depot had been closed, the small-pox is disappearing."

The annex of the Hotel Dieu being closed, the small-pox patients were sent to another hospital, and M. Bertillon says:

"Attention is directed to the ravages of small-pox in the quarter of Quinze Vingts, and the neighborhood of Sainte Marguerite and La Roquette. These districts continue to register three or four times their due amount of small-pox. These ravages are but too easily explained by the presence of the St. Antoine Small-pox Hospital, which has replaced the annex of the Hotel Dieu. During the first three months of the year the hospital contained 100 small-pox patients, and thus the contagion with which the annex of the Hotel Dieu was poisoning the Sorbonne was moved to these quarters. The contagion was imported with the patients by the administration, who thus furnished an experimental proof of our former conclusions."

M. Miquel's examination of dust and soil shows that these swarm with bacteria, and that, as regards dust deposited on free surfaces, it contained bacteria unproportional to the richness, in that respect, of the air whence the dust was deposited.

The Mont Souris experiments clearly show that the number of living organisms in the air are in direct proportion to the density of population. On mountain solitudes they are fewest; at points elevated above crowded cities they are comparatively scarce; at the Park of Mont Souris, on the outskirts of Paris, they are far less numerous than in the center of Paris, as in the Rue de Rivoli; and the numbers in the Rue de Rivoli, large as they are, become insignificant when compared with the quantity detected in the air of crowded dwellings and of hospitals. We have seen that in crowded cities, and still more in crowded rooms and homes, carbonic acid is present in the air in greater or less extent, and we have come to the conclusion that the carbonic acid *per se* is probably not very harmful, but that carbonic acid always comes in bad company, specially in the company of organic matter, which gives the close, organic smell to crowded places. Part at least of the organic matter is, we now know, composed of micro organisms, such as micrococci, bacteria, and bacilli.

Why should we attach so much importance to these micro organisms? There are a great variety of them, and the differences of their appearances are so slight that by the eye alone, even when aided by the highest powers of the microscope, it is impossible to distinguish many of them apart. Many of them play a part in the economy of nature which we must all recognize as of the highest importance. They are the great agents of putrefaction and decay; they are the active cause, as it were, of the breaking up of effete organic matter into its simple chemical elements. They are essential for the complete round of changes which we see going on around us. The animals prey upon each other, and on plants. The plants live on organic refuse, both animal and vegetable, but before organic refuse can become fit food for the higher plants, it becomes the prey of those low vegetable organisms which are the cause of putrefaction and decay, and which are to be found in the air, the water, and the soil, ready at all times to perform their mission.

It used to be thought that in order to stop putrefaction and decay, the "exclusion of the air" was, before all things, necessary. It has of late years been proved that the gases of the air are powerless, of themselves, to produce putrefaction, decay, or the allied process of fermentation; and that if the air be freed from micro-organisms, putrescible matter will remain unchanged for months, or years.

When an organic body ferments, or putrefies, then things happen which cannot but demand our attention. These are: (*a*) the giving off of gas, which is mainly carbonic acid, but which may be mixed with other offensive smelling gases; (*b*) the multiplication of the organism which is the cause of the ferment, so that the fermenting or putrefying mass becomes a focus for the dissemination of the organism; (*c*) a chemical change in the fermentable body. During vinous fermentation, alcohol is formed; and during some forms of putrefaction, bodies of the nature of alkaloids are formed, which are actively and quickly poisonous.

Ordinary putrefaction has long been recognized as an occasional danger to health, and irritant poisoning from eating putrid food is no very rare occurrence. What is known as "antiseptic surgery," which we owe to the genius of Sir Joseph Lister, consists in measures calculated to prevent putrefaction in wounds, whether the result of accident or the surgeon's knife. The putrefying of the wound is the cause of blood poisoning and death, and it is now known that if a wound can be kept sweet, it is hardly a source of danger to the patient, no matter what its extent may be. A putrefying wound may cause death in two ways: 1, by the entrance of the organism into the blood of the patient, and its subsequent growth in his body, and 2, by the absorption of the poison which is formed during putrefaction. In the former case death is gradual, and in the latter case it is sudden.

By the skill of experimenters, many of the micro-organisms have been differentiated and propagated by pure cultivation in fluids and semi-solids of a suitable constitution, and in this way, assisted by other methods of experiment, it has been shown that particular organisms are invariably associated with certain diseases, and that in some cases the organism is the veritable cause of the disease.

Thus it may be considered as proved beyond doubt that erysipelas is due to the growth of a micrococcus in the skin, and that splenic fever of cattle is due to the growth of a bacillus in the blood. Definite micro-organisms have been discovered to be inseparably connected with tubercular disease, pneumonia, glanders, relapsing fever, ague, typhoid fever, and it is only a matter of fair inference that if the case is proved in regard to a large number of these infective or zymotic diseases, a similar basis of causation will be found in connection with the others.

Since micro organisms are found to be definitely connected with disease, and since micro-organisms are found not only in the soil and water, but may be raised by the wind and transported any distance, the study of these organisms in the air is of prime importance from the point of view of health.

Now, the conditions of growth of these organisms have been studied with great care, and it is found that they only grow and flourish under certain conditions. The most important condition is a suitable amount of warmth and moisture. The most favorable temperature seems to be, broadly speaking, between 60° Fah. and 100° Fah. Cold checks their growth, as likewise do high temperatures.

We know how putrefactive changes run riot when the weather is warm and moist, and the history of cholera, plague, and yellow fever shows what may be the ravages of zymotic disease in tropical climates; and the recent researches into the life history of micro-organisms makes it impossible for us not to see the strongest analogy between the two conditions.

While the evidence that many diseases which affect the human race are caused by the growth of parasitical fungi in the tissues of our bodies is so strong, and is gathering strength so fast, as to be almost unanswerable, we have to remember that for the growth of a micro-organism to produce disease, just as for the growth of a food plant, something more is necessary than spore or seed, moisture or temperature.

That something is a suitable soil. All agriculturists know that very small differences in soils make very great differences in the growth of plants. In one field we may have a stunted crop choked by weeds, and a prey to parasites, while in the next field we may have the same plant (showing a vigorous and healthy crop, a crop whose very vigor makes it difficult for weeds to flourish. On inquiry, we may find that the soil of the two fields was originally the same, but that the addition of a small quantity of suitable manure, ammonia, nitrates, phosphates, potash, lime, or what not, has caused a vigorous growth in the one case, while the want of it has prevented vigorous growth in the other case. This is an every day experience.

Messrs. Lawes and Gilbert have, for years past, been making most valuable experiments on the effects of different manurial bodies. With crops which take six or eight months to come to perfection, experiment is but a slow method of gaining knowledge; and it is evident that experiments made in the field must lack much of the exactness which is obtainable in the laboratory.

In Dr. Duclaux's admirable little work on "Fermentation," which was written at the request of the Council of the recent Health Exhibition, will be found an account of some experiments carried out by M. Raulin.

M. Raulin devoted his attention to one of the commonest mould fungi, the *Aspergillus niger*. The spores of this fungus, when sown in a suitable soil, soon produce a mass of white branching threads, the so-called mycelium; and then there appear the spore-bearing filaments, whose black *capitula* make the mass look like velvet. This fungus grows readily on pieces of bread moistened with vinegar, or on slices of lemon, and generally on acid fruits and liquids.

By a series of experiments, however, M. Raulin devised a liquid in which the *aspergillus* grew with the greatest uniformity, so that crops of the fungus grown on equal quantities and areas of the liquid differed from each other only to the extent of 5 per cent. The composition of Raulin's liquid for the growth of the *aspergillus* is as follows:

	Grammes.
Water	1,500·00
Sugar candy	70·00
Tartaric acid	4·00
Nitrate of ammonia	4·00
Phosphate "	0·60
Carbonate of potassium	0·60
" magnesium	0·40
Sulphate of ammonia	0·25
" zinc	0·07
" iron	0·07
Silicate of potassium	0·07

The growth requires free exposure to the air, as the fungus needs a good supply of oxygen. A temperature of nearly 35° C. is found to be most favorable to it; and it grows best when the liquid is spread in a layer of two to three centimeters of depth over a shallow porcelain dish. If under these conditions the spores be sown, we find in twenty-four hours that the liquid is covered with a white layer of mycelium; the fructification begins, and in three days the cycle of changes is complete, and the crop is ripe. The first crop is removed, and more spores are sown, and at the end of three days there is a second crop. The two crops are then dried, and are found to weigh twenty-five grammes and the nutritive liquid is exhausted.

Here, then, is an experiment on manures and soils which is complete in six days, and which is so manageable that thousands of experiments might be perfected within a year. Further, it has all the elements of exactness and precision.

Now, the growth of a plant is a struggle between it and other organisms. All organisms have their enemies and their parasites, and must destoy them or be destroyed by them. The *aspergillus* is no exception, but in Raulin's liquid it flourishes, and none of its enemies gets ahead. The *aspergillus* is stronger than its enemies, because it finds in Raulin's liquid all the elements which it requires. If one of these elements were to fail it would still live, but with difficulty, and its power of resistance would diminish. If several were to fail, then it would dwindle, fade, and make way for a neighboring species of a less exacting nature or having other requirements more easily fulfilled in a medium which has become a poor one for the *aspergillus*, but a rich one perhaps for the other species.

M. Raulin made comparative experiments, growing the plant (*a*) in the complete liquid and (*b*) in the liquid minus one or other of its constituents. Here are some of his results:

		Grammes.
1.	With the liquid complete	25·000
2.	" minus potassium	1·000
3.	" " phosphoric acid	0·125
4.	" " ammonia	0·002
5.	" " the zinc	2·005

The effect of the withdrawal of the zinc is most remarkable, when we consider that in the 7 milligrammes of the sulphate there are but 3·2 milligrammes of zinc, constituting the one fifty-thousandth part of the fluid. The action of such a minute quantity of metal represents an increase of 22·5 grammes to the crop, *i. e.*, a weight of plant equal to 700 times its own weight.

Further, it has been stated that the one-million-six-hundred-thousandth part of nitrate of silver stops the growth altogether, and so sensitive is the plant to the action of silver, that the growth will not even commence in a silver vase. The growth is similarly stopped by one fifty-thousandth part of corrosive sublimate, by one eight-thousandth of bichloride of platinum, and one two-hundred-and-fortieth of sulphate of copper.

The withdrawal of iron from the liquid produces results similar to the withdrawal of zinc, while the addition of 1 gramme of iron to the liquid will increase the crop by 8·0 grammes. Notwithstanding this, the functions of the zinc and iron are quite different. Zinc enters the plant as one of its constituent elements, iron does not. The use of the iron is said to be to destroy or suppress, pending production, a poison which the plant secretes, and which, were it to accumulate, would end by killing the plant.

These experiments of Raulin's are most instructive, as showing us what apparently insignificant trifles may cause an organism to flourish or languish. Many of the micro-organisms connected with disease are cultivated with ease in artificial media, while the attempt to cultivate others has proved unsuccessful. This want of success is not to be wondered at, when we consider the effect of one one-million-six-hundred-thousandth part of nitrate of silver in checking the growth of the *Aspergillus niger*.

The effect of the minimal quantities of certain ingredients in "soils" (using the word as signifying all propagating media) enables us to frame an hypothesis for the explanation of certain phenomena connected with disease. Why is it, for example, that many of the zymotic diseases only occur, as a rule, once in a lifetime, and that one attack is preventive of subsequent attacks? This strange phenomenon is readily explained if we may assume that the micro-organism or zyme, by its growth, deprives the blood or the tissues of some ingredient (absolutely insignificant) without which the disease germs cannot flourish.

If, after the lapse of time, this hypothetical ingredient reaccumulates, then the body is ripe for a second attack of the malady. In like manner the effect of minimals on the growth of organisms may afford an explanation of why it is that zymotic diseases become epidemic, why at one time they involve a small area, and at another time a large area, and yet the cause may elude our coarse vision. In the old days, when it was the fashion to inoculate for the small-pox, the inoculated disease was generally milder and less dangerous than the disease contracted in the ordinary way, the reason being probably that when the disease was inoculated, the patient's body was not in the highest state of efficiency for growing small-pox, if such an expression may be used.

The effect of minimals on the growth of organisms may afford an explanation of why it is that some diseases seem to flourish more in some families than in others. Why, for example, does scarlet fever fall heavily on some families for successive generations, and how comes it that consumption, which is almost certainly dependent on an organism, is so clearly hereditary? If we may assume that what is known as "family constitution" is an aptness on the part of the blood and tissues to grow this or that organism, the explanation is easy.

Seeing how omnipresent are the micrococci, bacteria, and bacilli, of which we have been speaking, how they infest the air, the soil, the water; and seeing again that it is an undoubted fact that the organisms of disease may live and grow in suitable putrescible liquids outside the human body, it is almost a matter of surprise that we are any of us alive to discuss the question. From what we have been saying, however, it appears that for the flourishing of infective organisms three things are necessary in addition to the organism, viz., some degree of warmth, a suitable condition of moisture, and a "soil" apt to grow the organism. It is when we get the coincidence of all the conditions that we get the disease in its marked form. The cold of the Arctic winter seems to be sufficient to prevent putrefaction, and to prevent the spread of many of the zymotic diseases. In tropical countries, where putrefaction flourishes, zymotics flourish, and if we want to enjoy health in hot countries, we must exercise the greatest care and circumspection in dealing with all putrescible matters, whether excremental or otherwise. Finally, it is only unhealthy persons who become a prey to parasites, and a healthy man is probably more than a match for most of the so-called pathological organisms.

[THERAPEUTIC GAZETTE.]

THE TREATMENT OF PHTHISIS BY SULPHURETED HYDROGEN.*

By H. C. WOOD, M.D.

IT has not been many years since the faces of patients in a consumptive hospital were merged into a uniform ugliness, each, in fact, being cased in a mask of greater or less proportion, with various machinery in its center, which was dignified by the name of a respirator. It is noteworthy that the respirator was armed with germicides or antiseptics, and was to cure consumption antiseptically. Now, the destroyer of phthisis germs and the characteristic phenomenon of the pulmonic hospital bids fair to be a caoutchouc bag, a bottle of bad-smelling solution, and a rectal tube and nozzle. Whether this last claimant for therapeutic favor shall, as is not improbable, finally follow the respirator into oblivion or not, is at present uncertain. But the matter certainly is of sufficient importance to require careful treatment at the hands of the *Therapeutic Gazette*.

In 1883, M. Debove, professor at the *Hopital de la Pitie*, declared in one of his clinical lectures that consumption being due to the presence of a parasite, the proper treatment of it was the use of a parasiticide. It was left, however, for M. Bergeon (of L'Ecole de Medecine of Lyons) to put into actual practice this suggestion, and on the 12th of July, 1886, he gave his results to the French Academy of Science. He rejected the lungs themselves as the channel through which the parasiticide should find entrance into the system, on account of the rapidity of absorption from them, and of the fact that medicines taken up by them are carried immediately in a concentrated form to the right side of the heart, and, moreover, exert in the lung itself a too great local irritant influence. The disagreeable tastes of most of the antiseptics render their administration through the mouth and stomach difficult, while the work of Claude Bernard has shown that gaseous substances taken into the large intestine are absorbed with great rapidity and go into the general system. M. Bergeon, led by this train of thought, used various substances, such as chlorine, turpentine, ether, ammonia, and bromine injected into the rectum, but found them all so violently irritating that they had to be abandoned, but at last he discovered that a mixture of carbonic acid and sulphureted hydrogen was perfectly tolerated by the intestines, if the gases be pure and be unmixed with atmospheric air. Under these circumstances the role of the carbonic acid was to act as a diluent to the sulphureted hydrogen.

The apparatus of M. Bergeon consisted of a caoutchouc bag having a capacity of four or five liters, which was filled with pure carbonic acid and connected with a Woiffe's bottle, which was in turn connected with the tube inserted into the rectum of the patient, so that by compressing the bag the carbonic acid could be forced to bubble through the solution of sulphureted hydrogen, natural or artificial, in the Woiffe's bottle, and pass into the intestines. The common suphurous waters, especially Eau de Bonnes or Eau de Challes, were thought by Bergeon to be superior to any artificial waters, but this is probably a mistake.

In the Hopital Cochin, where the method has been much practiced, the following two solutions have been employed:

SOLUTION NO. 1.

℞ Sulphide of sodium, pure, 10 grammes, or 10 parts by weight;
Distilled water, enough to make 100 cubic centimeters, or 100 parts by weight.

One cubic centimeter of this liquid engages exactly ten cubic centimeters of sulphureted hydrogen when there is added to it one cubic centimeter of the following solution (No. 2):

SOLUTION NO. 2.

℞ Acid, tartaric, 25 grammes, or 25 parts by weight;
Acid, salicylic, 1 gramme, or 1 part by weight;
Distilled water, enough to make 100 cubic centimeters, or 100 parts by weight.

This solution in the Hopital Cochin is used by an apparatus which, under the directions of Dujardin-Beaumetz, is made by H. Gallante, of Paris, and which, though much more complicated, is, no doubt, more convenient than the apparatus of Bergeon. A description of this apparatus, with figure, may be found in *Les Nouveaux Remedes*, November 24, 1886.

By M. Bergeon himself four or five liters of carbonic acid gas, which had been passed through two hundred and fifty to three hundred grammes of the sulphurous mineral water, were thrown into the rectum twice in each twenty-four hours. In the Hopital Cochin the amount of gas injected varies from one to four liters at each seance. The apparatus used at this hospital is superior to that used in the original method, because it allows a definite amount of sulphureted hydrogen to be introduced with the gas. The amount of sulphureted hydrogen used in the Hopital Cochin is not positively stated, but about fifteen cubic centimeters of the solution of sulphide of sodium (equivalent to one hundred and fifty cubic centimeters of sulphureted hydrogen) seems to be the amount employed at a seance.

In his original communication, M. Bergeon claimed that the success of this mode of treatment is very rapid and remarkable. It is stated that the cough immediately diminishes, the expectoration lessens or even ceases, the appetite increases, the sleep becomes undisturbed, the fever abates, and the bodily weight greatly increases.

In the discussion before the Societe de Therapeutique, at the meeting of December 8, 1886, Dujardin-Beaumetz confirmed the statements of M. Bergeon, and, further, said that the amelioration must be due to the sulphureted hydrogen, as he had repeatedly tried injections of pure carbonic acid without doing good.

The French reports indicate very strongly that the drug acts, not as was originally expected, upon the parasite of phthisis, but upon the inflamed diseased lung tissue itself, since Dujardin-Beaumetz states that there is no lessening in the number of bacilli in the sputa; moreover, great benefit is obtained in the treatment of cases of simple chronic bronchial catarrh. This is also confirmed by the studies of M. Chentemesse, of the Hopital St. Antoine, who affirms distinctly that there is no lessening of the bacilli, and that very marked relief has been afforded to asthmatic patients. Moreover, *no evidence is forthcoming to show that sulphureted hydrogen is poisonous to the tubercular bacillus.* It is, so to speak, the natural gas of putrefaction, and, without definite proof, cannot be considered to be even probably inimical to low organic forms.

Dr. James Henry Bemett has published in the *British Medical Journal*, December, 1886, a paper upon Bergeon's method of treatment, in which, however, he adds nothing to our knowledge of the subject, merely stating his own experience in a single case of asthma.

In this city the method of treatment has been used in the Philadelphia Hospital in a large number of cases, especially in the wards of Dr. Bruen. A personal inspection of the result shows that the statements made by the French observers are correct, and there seems to be no doubt that under the treatment there is rapid alteration of some cases of phthisis for the better. In the Philadelphia Hospital the solution at first used contained five grains of the chloride of sodium and five grains of the sulphide of sodium, but at present the strength has been doubled, so that in the Woiffe's bottle, through which the carbonic acid passes, ten grains of each of the chemicals are put. Once charging of the Woiffe's bottle is made to suffice for a number of patients, each of whom receives at each treatment from three to five pints of carbonic acid. It will be seen at once that in this method the amount of sulphureted hydrogen received by the patent is unknown and variable, and is very small. A personal inspection of the carbonic acid used showed that it is very impure, the odor indicating that it contains sulphurous acid. Chemical testing has shown that the gas coming from the Woiffe's bottle contains sulphureted hydrogen, the odor of which is also distinctly present. The chloride of sodium in the solution would appear to be superfluous, the carbonic acid reacting directly with the sulphide of sodium. The following formula represents the probable change:

$$NaS + CO_2 + H_2O = NaCO_3 + H_2S.$$

Such is the evidence which I have been able to gather from the experience of others in regard to Bergeon's treatment, and it is sufficient to indicate that we are in the presence of a very important improvement of, or rather a very important addition to, medical therapeutics. It is of vital importance to decide the mode in which the treatment acts. The experiments of Dujardin-Beaumetz show that the carbonic acid is not the active agent, and that the good achieved is produced by the sulphureted hydrogen. Reasons already assigned are sufficient to make it improbable that the good achieved is the result of any parasiticidal influence. All clinical experience indicates that heredity is in the production of consumption a vastly more important factor than is any poison introduced into the body from without. Only a portion of the medical profession believes in the active contagiousness of phthisis, while the experience of any life insurance company affords a firm foundation for the belief in the heredity of the disease. If the bacilli really are the exciting cause of phthisis, the susceptibility to their action must be a more important factor in the production of phthisis than are the bacilli themselves. There is at present, then, no proof that the sulphureted hydrogen, when it does good in phthisis, acts by killing the bacilli, and there is still less proof that it in any way increases the direct resistive powers of the individual to the action of the bacilli. In some acute and chronic diseases of the skin, local applications of sulphur act with astonishing rapidity and effectiveness, and the thought naturally suggests itself that in Bergeon's treatment of consumption good is achieved by the action of the sulphureted hydrogen upon the inflamed lung tissue, or, in other words, that the plan of treatment is simply a means of making an application of sulphur to the pulmonic mucous membrane and tissue. This thought is not merely of speculative interest, but also of practical importance, for it suggests that the method of treatment will prove of value not only in consumption but in various forms of chronic or subacute affections of the lungs. This is confirmed by what experience we have. Cases of asthma and pulmonic catarrhs have already been quoted in this article as having been published in the French journals, in which the remedy has proved of the greatest service.

I saw in the Philadelphia Hospital one case of asthma with chronic catarrh and emphysema, in which the administration of the rectal injections had been followed by the most pronounced relief. In another case, of catarrhal pneumonia, with an enormous amount of purulent expectoration, and general symptoms so bad that a fatal prognosis had been given, the administration of the remedy was at once followed by rapid lessening and even cessation in the purulent secretion, and in a short time by convalescence.

As an important illustrative case, I cite one from my own recent experience. Mrs. L., over 70 years of age, received a severe contusion of the side in a railway accident, which was followed by pleurisy, in turn followed by bronchial pneumonia, with an enormous expectoration. She has been under my care for nearly three months, and though often temporarily benefited by various remedies, had failed to properly respond to the most careful treatment that I could give her. The expectoration remained exceedingly profuse, amounting sometimes to a pint in the course of twenty-four hours, although very irregular. The general symptoms were very bad; sinking spells were frequent and alarming. I finally told the family that she would die, unless the gaseous injections would do something for her. Within forty-eight hours after the use of the gas, the expectoration notably decreased; the expression of the patient's face changed entirely, and at present writing, fifteen days after the use of the sulphureted hydrogen, she is expectorating not one-sixth the quantity she did formerly, has regained the natural expression of her face and color of her skin, as well as her appetite and a fair amount of strength, and seems to be convalescent. A notable fact in this case is that the injections of gas relieve in a few minutes the sense of suffocation and sinking the patient formerly felt in the mornings. The secretion of urine was sensibly increased. As tested on three occasions, the subnormal temperature rose 0·4° F. within the half-hour after the exhibition of the gas either by the mouth or rectum.

One difficulty with Bergeon's method of treatment in private practice is the cumbersomeness of the apparatus and the skilled labor required for the preparation of the carbonic acid. A plan which would avoid this and reach the same result in regard to the lung disease is certainly a desideratum.

According to Gay-Lussac and Thenard, water at 52° Fahrenheit will absorb three times its volume of sulphureted hydrogen. To prepare this solution, the gas, previously washed with water, is passed alternately through each of two bottles half filled with water; while it is being passed through one, the other is closed with the stopper and shaken, to insure complete absorption; and thus the process is continued till the water is completely saturated. One of the bottles is then completely filled with the liquid, and removed with the mouth downward. The resulting solution is a colorless liquid, having the odor of putrid eggs and a sweetish taste. When heated, it evolves the whole of the gas. Bottles containing the solution of sulphureted hydrogen should be habitually laid upon their side.

A priori, there is no evident reason why this solution, if injected into the rectum in proper doses, should not exert all the influence upon the pulmonic tissue obtained by Bergeon's treatment. I have tried the solution thrown into the rectum, and found it free from any irritant action. The habitual use of injections two or three times a day is, however, very disagreeable to most patients, and the questions naturally arise, Is there any necessity of administering the drug by the bowels, and Will not sulphureted hydrogen water be taken without too much repugnance by the mouth and without nauseating? At the various sulphur springs large quantities of such water are habitually drunk by the patients. Led by such considerations, I have tried the sulphureted hydrogen water in as many cases as I have been able to get, and so far, when properly given, it has been usually taken readily, and has not disagreed with the stomach. Some persons, however, will not tolerate it at all. The effects upon the disease have seemed to be entirely similar to those produced by the injections. At first a half ounce, afterward an ounce, of the saturated solution of the sulphureted hydrogen should be placed in a tumbler, and two or three ounces of carbonic acid water be run into it from a highly charged siphon, the whole being drunk while effervescing. This may be given three to five times a day, so that the patient will receive daily between a half pint and a pint of the sulphureted hydrogen gas. Injections of gas into the rectum produce, in some persons, more or less violent attacks of colic, especially if given at a time when the food is well down in the intestinal tract. Thus, in the case of Mrs. L., the night injection caused so much pain that it could not be borne, although the injection in the morning was actually pleasant. The two methods of administration were then combined, the gas injection being given in the morning and the sulphureted hydrogen water in the afternoon and evening. Within the last forty-eight hours, at Mrs. L.'s earnest request, the gas injections have been entirely abandoned in favor of the exhibition by the mouth. Of course, the two methods are simply different ways of accomplishing the same result, and may be variously combined or substituted for one another, according to the peculiarities of the individual cases within the last day or two.

It is a matter of the greatest importance to fix definitely the dose of sulphureted hydrogen gas. With the method employed in the Philadelphia Hospital this cannot possibly be done. The solution employed in the Hopital Cochin, whose formula is given in the first part of this article, seems to be superior to the solution of the chloride and the sulphide of sodium, in affording known quantities of sulphureted hydrogen. Even with it, however, the chemical reactions are so slow that practically it is scarcely possible to decide how much of the gas is evolved in a brief time. The substitution of sulphuric for tartaric acid would largely obviate this. When the medicine is given by the mouth, exact dosage is possible. In Mrs. L., five ounce doses appeared to be too much. She is now taking three doses daily.

In a recent number of the *British Medical Journal* it is stated that M. Morel affirmed before the Biological Society of Paris that the dose of the gas is twenty-five cubic centimeters. That it is not incapable of doing harm is shown by the experiments of M. Peyron, who injected into the rectum of a dog one hundred and fifty cubic centimeters of a saturated solution of sulphuretted hydrogen in two doses at intervals of three minutes. Symptoms of poisoning began to be manifested within two minutes, and death took place in ten minutes.

Another dog died quickly after two injections of the same strength, given at intervals of twelve minutes, while two others, in whom only very small quantities of the gas, or large quantities very much diluted, had been injected, experienced only slight inconvenience, and rapidly recovered. Not long since, in the University Hospital in Philadelphia, about one quart of a mixture containing equal quantities of carbonic acid and sulphureted hydrogen were injected into the rectum of a patient; within three minutes the man was unconscious and apparently dying. The breathing rate was one hundred per minute, and the respirations so shallow that they could scarcely be observed. The pulse at once became very rapid and feeble, and even imperceptible at the wrist, while a very marked odor of sulphureted hydrogen appeared in the breath. Under treatment the symptoms all subsided in about fifteen minutes. The rapidity with which these symptoms developed and with which they subsided indicates that when the gas is thrown into the rectum its effect is very immediate and fugacious, and it is entirely possible that the more continuous influence of rectal injections of the aqueous solution of sulphureted hydrogen may act better in pulmonic diseases than does the short influence of the gases now administered. Of course, poisoning by overdoses of sulphureted hydrogen is a no more valid objection to its proper use than is opium poisoning to the employment of opium.

1925 Chestnut St., Philadelphia, April 2, 1887.

NOT the least of the many novel uses to which paper, so-called, has been put in the arts, is the manufacture of pulleys for transmitting power. The advantages gained are lightness and, it is stated, increased draught. In weight alone the saving is great: a paper pulley weighing only 50 lb. against 90 lb. for cast iron of the same size.

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* Dr. V. Morel, "Nouveau Traitement des Affections des Voies Respiratoires," Paris, 1886. *Gazette Hebdomadaire*, December 17, 1886. *La Semaine Medicale*, July 14, 1886; October, 1886.

THE CASTNER SODIUM PROCESS.*

HAVING been engaged professionally during the past few months in assisting in the development of this process, through the kind permission of Mr. Castner I am enabled to present to this society its details, together with a few facts concerning the uses and cost of manufacturing sodium and potassium.

The process heretofore exclusively used for the production of these two metals is so well known that anything more than a brief reference is hardly necessary.

By the older process, carbonate of soda, charcoal, and lime, in the proportion of 30, 13, and 7, are made into the finest and most intimate mixture, and then calcined at a red heat, to render the mixture more compact, which also expels a considerable amount of carbonic oxide. This calcined mixture is then introduced into wrought iron cylinders of small diameter, and heated to a temperature of about 1,400 deg. C., whereby the alkaline metal is reduced and distilled from the cylinder containing the charge through a small tube provided for the gases and vapors into the receptacle known as the condenser. Through a variety of causes, not more than forty per cent. of the metal contained in the charge is obtained, and in the manufacture of potassium very much less. The wear and tear on the metal cylinders is enormous, and forms a large proportion of the cost of manufacture. To carry out this process and arrive even at these results, requires—

As near as I can ascertain at present, sodium costs about 4s. per pound to produce, the following being the chief items:

	s.	d.
Wear and tear to furnaces, cylinders, etc..	2	0
Materials—owing to loss and waste........	1	0
Labor..	0	8
Fuel..	0	4

Since Mr. Castner's paper upon his process, which was read before the Franklin Institute of Philadelphia, October 12, 1886, several slight changes in the mode of carrying on this process have been made. These have been brought about by the experience gained from the actual working of the process upon a commercially large scale.

The reactions by which the sodium and potassium are produced are somewhat difficult to describe, as they vary somewhat, according to the mixture of materials and temperature employed in the reduction. The mixture and temperature which it is now preferred to use is represented by the reaction:

$$6NaHO + FeC_2 = 2Na_2CO_3 + 6H + Fe + 2Na$$
$$6KHO + FeC_2 = 2K_2CO_3 + 6H + Fe + 2K$$

In place of using an actual chemical compound of iron and carbon, as expressed by the above reaction, a substitute or equivalent is prepared as follows:

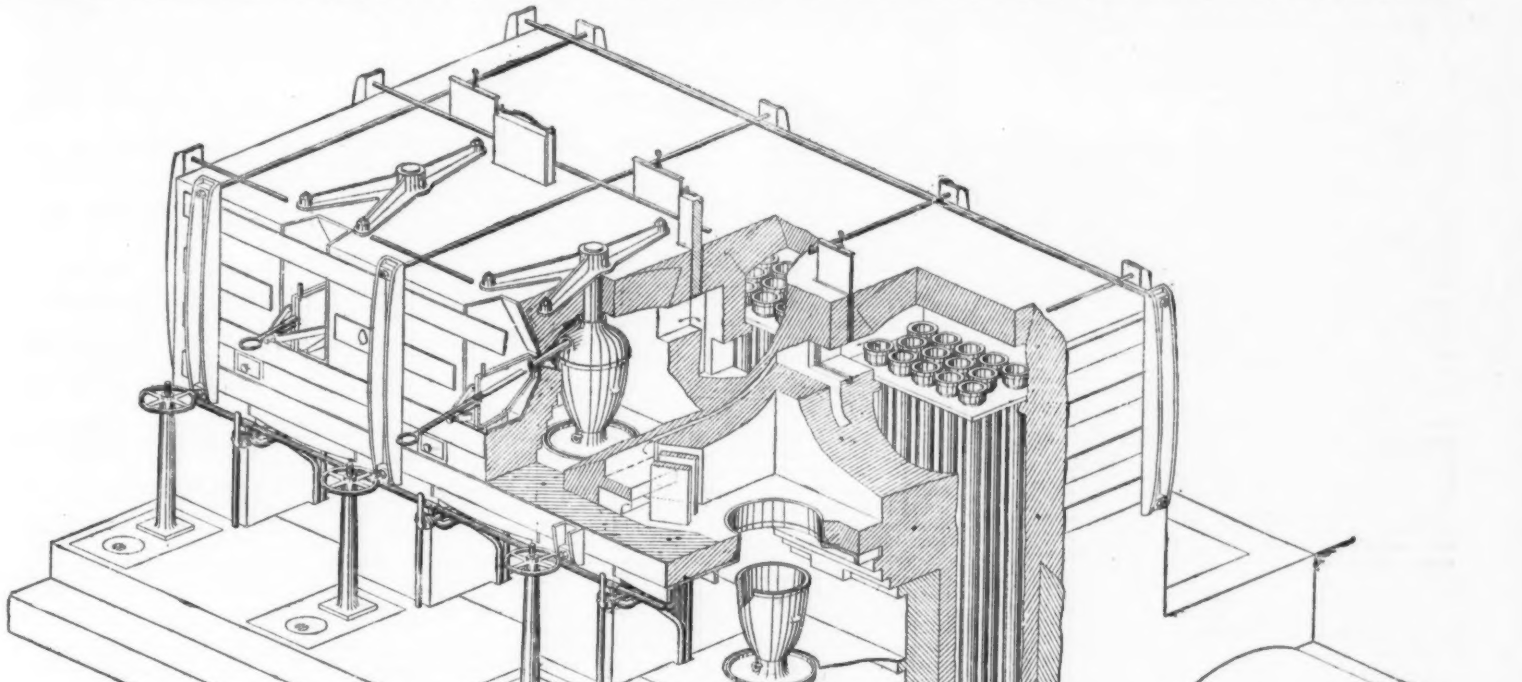
To a given quantity of melted pitch is added a definite proportion of iron in a fine state of division. The mixture is cooled, broken up into lumps, and coked in large crucibles, giving a metallic coke, consisting of carbon and iron, the proportions of each depending upon the relative quantities of pitch and iron used. This metallic coke, after being finely ground, provides a substance having the iron and carbon in a like proportion to an iron carbide, and from which neither the iron nor carbon can be separated by mechanical means. The fine iron is conveniently prepared by passing carbonic oxide and hydrogen, in a heated state, as obtained from an ordinary gas producer, over a mass of oxide of iron, commercially known as "purple ores," heated to a temperature of about 500 deg. C.

In producing sodium, caustic soda of the highest obtainable strength is used, and there is mixed with it a weighed quantity of the so-called "carbide," sufficient to furnish the proper amount of carbon to carry out the reaction indicated above. The crucibles in which this mixture is treated are made of cast steel, and are capable of containing a charge of 15 lb. of caustic soda, together with the proper proportion of the "carbide."

After charging a crucible with the above mixture, it is placed in a small furnace, where it is kept at a low heat for about thirty minutes, during which time the mass fuses, boils violently, and a large part of the hydrogen is expelled by the combined action of the iron and carbon, the "carbide," owing to its gravity, remaining in suspension throughout the fused soda. At the end of the time stated, the contents of the crucible have subsided to a quiet fusion. The crucible is then lifted, by a pair of tongs on wheels, and placed upon the platform of the elevating gear, as shown in the drawing, and raised to its position in the heating chamber of the main distilling furnace. The cover, which remains stationary in the furnace, has a convex edge, while the crucible has a groove round the edge, into which the edge of the cover fits. A little powdered lime is placed in the crucible groove just before it is raised, so that when the edges of the cover and crucible come together, they form a tight joint, and, at the same time, will allow the crucible to be lowered easily from the chamber when the operation is finished, to give place to another containing a fresh charge. From the cover projects a slanting tube (as shown) connected with the condenser. The condenser is provided with a small opening at the further end, to allow the escape of hydrogen, and has also a rod fixed (as shown), by means of which any obstruction which may form in the tube during distillation may be removed. After raising a crucible in its place in the furnace, the hydrogen escaping from the condenser is lighted, and serves to show by the size of the flame how the operation is progressing in the crucible, the sodium actually distilling soon after the crucible is in its place. The temperature of the reduction and distillation has been found to be about 823 deg. C. The gas coming off during the first part of the distillation has been analyzed and found to consist of pure hydrogen. An analysis of the gas sample taken when the operation was almost completed gave as a result: hydrogen, 95 per cent.; carbonic oxide, 5 per cent. It has been found advisable to use a little more "carbide" than the reaction absolutely requires, and this accounts for the presence of the small quantity of carbonic oxide in the expelled gas, the free carbon acting upon the carbonate formed by the reaction, thus giving off carbonic oxide, and leaving a very small percentage of the residue in the form of peroxide of sodium. This small amount of carbonic oxide rarely combines with any of the sodium in the tube, and so the metal obtained in the condensers is pure, and the tubes never become choked with the black compound. In the preparation of potassium a little less "carbide" is used than the reaction requires. Thus no carbonic oxide is given off, and all danger attached to the making of potassium is removed. After the reduction and distillation the crucible is lowered from the furnace, and the contents poured out, leaving the crucible ready to be recharged. The average analyses of the residues show their composition to be as follows:

Carbonate of soda.	77	per cent.
Peroxide of sodium................	2	"
Carbon..................................	2	"
Iron.......................................	19	"

The average weight of these residues from operating upon charges of 15 lb. caustic soda and 5¼ lb. of carbide is 16 lb. These residues are treated either to produce pure crystallized carbonate of soda or caustic soda, and the iron is recovered and used again with pitch in the formation of the "carbide." From this residue, weighing 16 lb., is obtained 13 lb. of anhydrous



CASTNER'S SODIUM FURNACE.

1st. The most careful grinding and mixing of ingredients.

2d. The addition of lime to prevent fusion.

3d. An excess of carbon to insure contact between the particles of soda and carbon in the refractory charge.

4th. Previous calcination to make the charge less bulky.

5th. Wrought iron must be used in constructing the cylinders, being the only metal practical to use that will stand the high temperature.

6th. Cylinders must be used of small diameter, so as to allow the heat to penetrate to the center of the refractory charge.

7th. The exit tubes from the cylinders to the condensers require the most careful attention to keep them open, owing to the formation of the black compound formed by the action of carbonic oxide upon the vapor of the alkaline metal, which combination takes place at about the condensing point of the metallic vapor.

This is one of the most serious obstacles to be met with in the course of manufacturing sodium, not only causing a large loss of metal, but interfering generally with the operation. In the making of potassium, the formation of this compound, which is exceedingly explosive, and which is produced even more readily than when making sodium, is the chief reason that this metal costs almost ten times as much as the same quantity of sodium.

* An address read by Mr. James Mactear, F.C.S., at the meeting of the Society of Chemical Industry, London, March 7, 1887.

carbonate of soda, equivalent to 9·4 lb. caustic soda of 76 per cent.

Operating upon charges as above mentioned, the yield has been:

Sodium, actual...	2·50 lb.	Theory..	2·85 lb.
Soda, carbonate, actual..	13·00 lb.	" ..	13·25 lb.

The average time of distillation in the large furnace has been 1 hour and 30 minutes, and, as the furnace is arranged for three crucibles, 45 lb. of caustic soda are treated every 90 minutes, producing 7½ lb. of sodium and 39 lb. of carbonate of soda. The furnace is capable of treating 720 lb. of caustic soda daily, giving a yield, in 24 hours, of 120 lb. of sodium and 624 lb. of anhydrous carbonate of soda. The furnace is heated by gas, which is supplied by a Wilson gas producer, consuming 1 cwt. of fuel per hour. The small furnace, in which the crucibles are first heated, requires about ½ cwt. per hour. The following estimate of cost, etc., is given from the actual running of the furnace working with the above charges for 24 hours:

	£	s.	d.
720 lb. of caustic soda @ £11 per ton....	3	10	10
150 lb. of "carbide" @ ½d. per lb.. ..	0	6	4
Labor	1	0	0
Fuel..	0	17	0
Reconverting 624 lb. of carbonate into caustic, at a cost of about £5 per ton on the caustic produced, say.........	1	0	0
Total...........................	£6	14	2
Deducting value of 475 lb. of caustic recovered..............	2	6	8
Cost of 120 lb. of sodium..............	£4	7	6

Cost per pound 8¼d.

Regarding the item of cost relating to the damage caused to the crucibles by the heat, this question has been very carefully gone into. Some of the crucibles have been used upward of fifty times, and, from present indications of their condition, there is no doubt that they can continue to be used at least one hundred and fifty times more before they become unfit for further use. In considering 200 operations to be the life of a crucible, the item of damage or wear and tear amounts to less than 1d. per lb. on the sodium produced, and, if we take the furnace tear and wear at the same rate of 1d. per lb., we shall see that the tear and wear of plant is only one-twelfth of that incurred in the ordinary process. It is upon these facts that Mr. Castner bases his claim to be able to produce sodium by his process, upon the large scale, at a cost of less than 1s. per lb. The advantages of this process will be apparent to any one at all familiar with the manufacture of these metals as conducted heretofore. The first and most important end gained is their cheap production, and this is owing chiefly to the low heat at which the metals are produced, the quickness of the operation, non-clogging of the conveying tubes, and a very small waste of materials. The process, furthermore, admits of being carried on upon a very large scale, in fact it is intended ultimately to increase the size of the crucible, so as to make the charges consist of 50 lb. of caustic soda. Crucibles of cast iron have been found quite suitable, and it is intended in future to use crucibles made of this material in place of the more expensive steel.

As regards potassium, it has hitherto been regarded very much as a chemical curiosity, and sells for about 60 shillings per lb. By this method the cost of the manufacturing operations is no more than for sodium, the higher cost of the caustic potash being the chief element of increased expense. The uses of these alkali metals are at present limited, owing to their high cost alone. Sodium is used somewhat largely in manufacturing aluminum, magnesium, silicon, etc., and in the formation of amalgams, while potassium is only used in small quantities as a chemical reagent. It will hardly be considered out of place, in concluding this paper, relating to the manufacture of sodium and potassium, to mention some few facts connected with aluminum.

This metal depends, at present, upon sodium for its production, and, consequently, any process successfully producing *cheap* sodium in reality allows of the manufacture of *cheap* aluminum. Notwithstanding all the efforts that have been made by various chemists and metallurgists for the past thirty years in endeavoring to invent some process for producing aluminum whereby that most interesting and valuable metal could be cheaply produced by a better process than that of Deville's, absolutely nothing has been accomplished that would even lead one to hope that some time in the future his process would be superseded. By employing Deville's process and using sodium as heretofore manufactured, the aluminum costs between 30 and 40 shillings per lb. Owing to this high price alone, the consumption is limited, and, therefore, the manufacturer is obliged to ask in selling the metal a relatively higher price in order to obtain anything like a fair profit upon the invested capital. The present selling price of aluminum varies between 50 and 60 shillings per lb., although every few months there appears in some newspaper the information that some parties (*unknown*) have contracted with other parties (*unknown*) for a large quantity of aluminum at prices varying between 10 and 30 shillings per lb. It is needless to say that upon inquiring the contracting parties cannot be found.

Aluminum, if placed upon the market at 20 shillings per lb., could, undoubtedly, be sold in large quantities, the demand rapidly increasing as the metal gained in favor, which, owing to its varied valuable properties, it would do to a certainty. It is allowed by all those familiar with the different items of cost in carrying out Deville's process, that, could sodium be obtained for one shilling per lb., aluminum could be made below a cost of 15 shillings per lb.

I think it is not, therefore, too much to claim for the "Castner process" of manufacturing sodium and potassium—now that it has been demonstrated commercially capable of producing sodium at one shilling per lb.—that it is the greatest advance in the direction of producing aluminum at a cheap rate which has been made since Deville first demonstrated the possibility of producing that metal on a commercial scale.

It has long been known that the distillation of the metal sodium is rendered more easy by the use of a proportion of potash in the mixture. It is also known that a series of alloys of potassium and sodium can be produced, several of which are liquid, having much the same appearance as mercury when under naphtha. These alloys are very curious, one of them remaining liquid at 0° C., while another is lighter in its specific gravity than naphtha, upon which it floats.

Specimens of several of these alloys, together with samples of the sodium and potassium as made by this process, are upon the table, and are open to your inspection.

ALKALI MANUFACTURE.

IN the well known Leblanc process a large proportion of the sulphur used in the conversion of the chloride of sodium into carbonate of sodium is lost, even when known or existing processes for the recovery of the sulphur are restored to. Moreover, considerable annoyance and inconvenience are caused by the unavoidable soda waste in the Leblanc process. Mr. E. F. Trachsel, of Upper Holloway, has therefore invented a process to obviate these defects or inconveniences, and to provide for the recovery of most of the sulphur as such (with scarcely any inherent cost), or for the use of the same for the making of the sulphuric acid required in the process. The waste in the Trachsel process is very small, and is entirely harmless, it being only some undecomposed sulphate of strontium or of barium mixed with the ashes of coal.

In practice Mr. Trachsel calcines an intimate mixture of sulphate of sodium and sulphate of strontium or of barium and coal or other like carbonaceous matter in suitable proportions for the reduction of the sulphates. He has obtained good results with 9½ cwt. of sulphate of sodium, 10½ cwt. of sulphate of strontium, and 8 cwt. of coal; but the proportions may be varied within very wide limits. He prefers to effect the reduction in a so-called "plus pressure" furnace or in a common reverberatory furnace. The resulting product is a mixture of sulphide of sodium with sulphide of strontium or of barium and undecomposed sulphate of strontium or of barium (if the decomposition has not been carried far enough to decompose the whole of such sulphate), together with the ashes of the coal. He lixiviates this product (after granulation or breaking up thereof, if necessary) with hot or warm water, and thus obtains a solution of sulphide of sodium and sulphide of strontium or of barium. This solution, on cooling, deposits (if sufficiently strong) most of its strontia or baryta in the form of hydrate of strontium or of barium, according to the equation—

$$Na_2\,S+Sr\,S+2\,H_2O=2\,(Na\,HS)+Sr\,(OH)_2$$
$$\textit{or}\ Na_2\,S+Ba\,S+2\,H_2O=2\,(Na\,HS)+Ba\,(OH)_2$$

in the case of strontium and barium respectively. This reaction of the sulphide of sodium upon the sulphide of strontium or of barium is an important and essential feature of the invention, as it is by this reaction that he is enabled to make his process, commercially successful. In carrying out the process Mr. Trachsel has found that in some cases, especially if the mixture has not been sufficiently calcined, the sulphate of strontium is only partially reduced to sulphide, and the consequence is that, besides sulphydrate of sodium, there is a proportion of sulphide of sodium left in the liquor. It is obvious that this sulphide of sodium, or sulphide of sodium obtained by other processes, can be used to decompose sulphide or sulphydrate of strontium according to the above mentioned reaction, and that the sulphide of strontium or sulphydrate of strontium can be obtained either from the residue of undecomposed sulphate of strontium from a former operation or by the reduction of a fresh quantity of sulphate of strontium, without the admixture of sulphate of sodium, or with only a small quantity of sulphate of sodium. The sulphydrate of strontium can be easily obtained by cooling a hot and concentrated solution of sulphide of strontium according to a process previously invented by Mr. Trachsel, and the action of the sulphide of sodium upon the sulphydrate of strontium would then be expressed by the equation:

$$2\,Na_2\,S+Sr\,(HS)_2+2\,H_2O=4\,(Na\,HS)+Sr\,(OH)_2$$

The hydrate of strontium or of barium is a valuable and readily salable article, which can easily be separated from the mother liquor, consisting of sulphydrate of sodium. The mother liquor is then boiled down, and, on cooling, deposits nearly all the strontia or baryta still contained in it. He thus obtains a strong solution of sulphydrate of sodium, which he subjects to the action of carbonic acid, by drawing or forcing through it carbonic acid gas, or gases more or less rich in carbonic acid, and thus produces carbonate of sodium. Strong solutions of sulphydrate of sodium are readily acted upon by carbonic acid, the action being:

$$2\,Na\,HS+CO_2+H_2O=Na_2\,CO_3+2\,H_2S.$$

The small quantity of strontia or baryta still left in the liquor separates out as carbonate of strontium or of barium, during the carbonating process. If the solutions are of a strength of about 30° Twaddell or more, which will depend upon the previous boiling down, the soda crystallizes out as carbonate with five (5) molecules of water of crystallization, but if the solutions are weaker than, say, 20° Twaddell, common soda crystals are obtained; or, if very weak solutions are used, no crystallization takes place. He prefers, however, to use the solution of sulphydrate of sodium as strong as possible, and in this case he separates the crystals of carbonate of soda from the remaining liquor, and makes the soda crystals ready for the market in the ordinary manner, while the weak liquor from which these crystals are obtained is boiled down, and, if not fully converted into carbonate, is returned into the carbonating apparatus. The sulphureted hydrogen given off during the carbonating process is easily converted into sulphurous acid by passing it through a "Claus" kiln, and the sulphurous acid can be used for making sulphuric acid. If the sulphureted hydrogen is not mixed with too great a proportion of oxygen, which depends on the composition of the gases used for carbonating, it can readily be converted into sulphur by passing it through a "Claus" kiln, or by some other suitable process. He thus recovers, either as sulphur or as sulphur dioxide, not only the sulphur from the sulphate of sodium, but also the sulphur from the sulphate of strontium or of barium used in his process. He sometimes uses sulphate of potassium instead of sulphate of sodium, the action being similar.

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